PARALLEL FUNCTION PROCESSOR
RELIABILITY TEST

SPECIAL TECHNICAL REPORT

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GUIDANCE, NAVIGATION AND CONTROL
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Georgia Institute of Technology

Atlanta, Georgia 30332 - 0540

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UL10301

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1. INTRODUCTION

A week long test was run on the Parallel Function Processor (PFP) Monday June 12, 1989 through Sunday June 18, 1989. Temperature data was collected over a 103 hour period from Tuesday June 13, 1989 through Saturday June 17, 1989 at 32 points on the system. Plots of 31 of these points are included in this report, the 11th thermocouple did not work correctly, giving all negative temperatures.

The system was run with 2 full crossbars, two sequencers, one array interconnect link (i.e., one board on each crossbar) and 45 processors. The remaining 17 processor slots were empty. The right processor bank was fully populated (31 processors, one array interconnect) with the remaining boards (14 processors, 1 array interconnect) on the left side.

Four diagnostic tests, T3, FPPMU, T2, and FUNCTION were run in a continuous loop for the whole week. Results are given in two forms, per test and per processor.

2. T3 TEST RESULTS

The T3 test is the comprehensive crossbar test. In it, one processor broadcasts a number over both crossbars (using one array interconnect link) to all other processors in the system. The host then reads the received number from each processor to verify the data that was received. Four 32 bit patterns (00000000, 55555555, AAAAAAAA, FFFFFFFF) are sent by a designated processor. Each processor becomes the sender every 45th cycle.

The total number of transfers was:

(45 processors)(44 xfers/subcycle)(4 subcycles/cycle)
(840 cycles)(11 loops) = <u>73180800 32 bit xfers</u>

The total number of bit errors was:

1 bit

The total bit error rate was:

1/(32 bits/transfer)(73180800) or 1/2,341,785,600

= 4.27 x 10^{-10} (error bits/transfer bits

3. FPPMU TEST RESULTS

The FPPMU test is the comprehensive test of the multibus repeater system. The host sends alternating patterns of 00000000, 55555555, AAAAAAAA, FFFFFFFF to each processor across the multibus and then reads the values back.

The total number of 32 bit transfers was:

(4800 xfers/cycle)(11 cycles) + 15,200 xfers = 68000 transfers

The total number of bits transferred was:

(32)(68000) = 2,176,000 bits

The total number of bits in error was:

0 bits

Thus the error rate was:

0.00 error bits/transfer bits

4. T2 TEST RESULTS

The T2 test was primarily written to aid in finding faulty processor/sequencer handshake cables. One processor acts as a central node sending alternating patterns of 00000000, FFFFFFFF to each processor individually. (Thus, each sequencer cable is checked individually.)

The total number of 32 bit transfers was:

234,000 transfers

The number of words in error was:

21 words

In addition there were two "hang up" errors for a total of:

23 errors

The error rate was:

23/234,000 or 9.829 x 10^{-5} Transfer Errors/Transfers

NOTE: 20 of the 23 errors occurred in one bunch. See the error summary table for details.

5. FUNCTION TEST RESULTS:

The function test consists of testing all functions that are hardware assisted on the processor by computing them remotely at each processor, as well as locally at the host, and then comparing the results. The following functions were computed at each processor on each cycle:

200 sine values
180 cosine values
180 tangent values
200 arcsine values
200 arccosine values
200 arctangent values
64 reciprocal values
102 exponential values
100 square root values
30 natural log values

This is a total of 1456 computed values per processor per cycle.

The total number of computed values was:

(250 iterations)(10 cycles)(45 processors)(1456) = 163,800,000

The total number of errors was:

28 values

This gives an error rate of:

28/163,800,000 = 1.709 x 10^{-7} Function errors/Function Computations

NOTE: All errors occurred in two bunches early in the test and then went away.

6. ERROR SUMMARY

Table 6.1 gives a summary of all errors by test and by processor. Two errors are not tabulated in Table 6.1. These occurred during the T2 test. These errors "hung up" the system and did not list to the printer. The system was reset after each of these errors and testing continued.

Table 6.1 ERROR SUMMARY PER PROCESSOR

ERRORS	PROCESSOR	FPPMU	T2	T3	FUNCTION	TOTAL
1	2050-15	0	0	0	0	0
2	2050-14	0	0	0	0	0
3	2050-13	0	0	0	0	0
4	2050-12	0	0	0	0	0
5	2050-11	0	0	0	24	24
6	2050-10	0	0	0	0	0
7	2050-09	0	0	0	0	0
8	2052-15	0	0	0	0	0
9	2052-14	0	0	0	0	0
10	2052-13	0	0	0	0	0
11	2052-12	0	0	0	0	0
12	2052-11	0	0	0	0	0
13	2052-10	0	0	0	0	0
14	2052-09	0	0	0	0	0
15	2052-08	0	0	0	0	0
16	2056-15	0	0	0	0	0
17	2056-14	0	0	0	0	0
18	2056-13	0	0	0	0	0
19	2056-12	0	0	0	0	0
20	2056-11	0	0	0	0	0
21	2056-10	0	20	0	4	24
22	2056-09	0	0	0	0	0
23	2056-08	0	0	1	0	1
24	2056-07	0	0	0	0	0
25	2056-06	0	0	0	0	0
26	2056-05	0	0	0	0	0
27	2058-15	0	1	0	0	1
28	2058-14	0	0	0	0	0
29	2058-13	0	0	0	0	0
30	2058-12	0	0	0	0	0
31	2058-11	0	0	0	0	0
32	2058-10	0	0	0	0	0
33	2058-09	0	0	0	0	0
34	2058-08	0	0	0	0	0
35	2058-07	0	0	0	0	0
36	2058-06	0	0	0	0	0
37	2058-05	0	0	0	0	0
38	2060-14	0	0	0	0	0
39	2060-13	0	0	0	0	0
40	2060-12	0	0	0	0	0
41	2060-11	0	0	0	0	0
42	2060-10	0	0	0	0	0
43	2060-09	0	0	0	0	0
44	2060-08	0	0	0	0	0
45	2060-06	0	0	0	0	0
Totals		0	21	1	28	50

7. TEMPERATURE DATA

Plots of all temperature measurements are given in Appendix A. As expected, the hottest point in the system is located on the floating point processor underneath the piggyback memory board. Differences in the temperature plots for the 5 thermocouples glued under memory boards are primarily due to the glue job holding them on the board. The thermocouples that appear coolest were insulated from the chip surface by glue while the warmer ones were in direct contact with the chip surface.

8. INTERPRETATION OF RESULTS/RECOMMENDATIONS

Forty-eight of the 52 errors were located on two processors. One of these (the processor from slot 2056-10) now has a hard failure, is no longer loadable, and has been removed from the system. These errors were all local processor and/or function board errors that do not reflect any system wide problem.

The two times the system hung up could be attributable to several problems. The two most likely candidates are 1) the two marginal processors hung something up, or 2) a power glitch caused by one of several thunderstorms which occurred during the week.

The one bit dropped during a T3 test looks like an honest error, and possibly one bit dropped by processor P13 during a T2 test may be an honest error.

The temperature data looks acceptable "as is" with the possible exception of the chips on the FPP board located under the piggyback memory board. The low 60 degree C range readings are getting very close to the 70 degree C rating on these chips. As previously discussed, I recommend we use military grade chips in this area which are rated at 125 degrees C.

Also, the location of the card cage in the cabinet (high, low, or middle) does not seem to affect the temperature of the processor board too much. The boards in the lower card cages seem to be running just as warm as the ones in the upper card cages.

Thermocouples #20 and #28 do not appear to have the same variance as the others. I have no explanation for this other than they may have experienced more or less noise (maybe some kind of direct metal to metal contact) than the other signals due to the way they were routed.

Thermocouples 14 and 16 are labeled correctly but we may have placed them in the wrong place. Thermocouple 16 follows thermocouple 13 very closely, leading us to believe we placed #16 above the top left chassis instead of the bottom left chassis. Thermocouple 14 looks like room temperature, which could be correct since the bottom left card cage it was located near only had a multibus repeater and an array interconnect in it.

9. SOURCE CODE

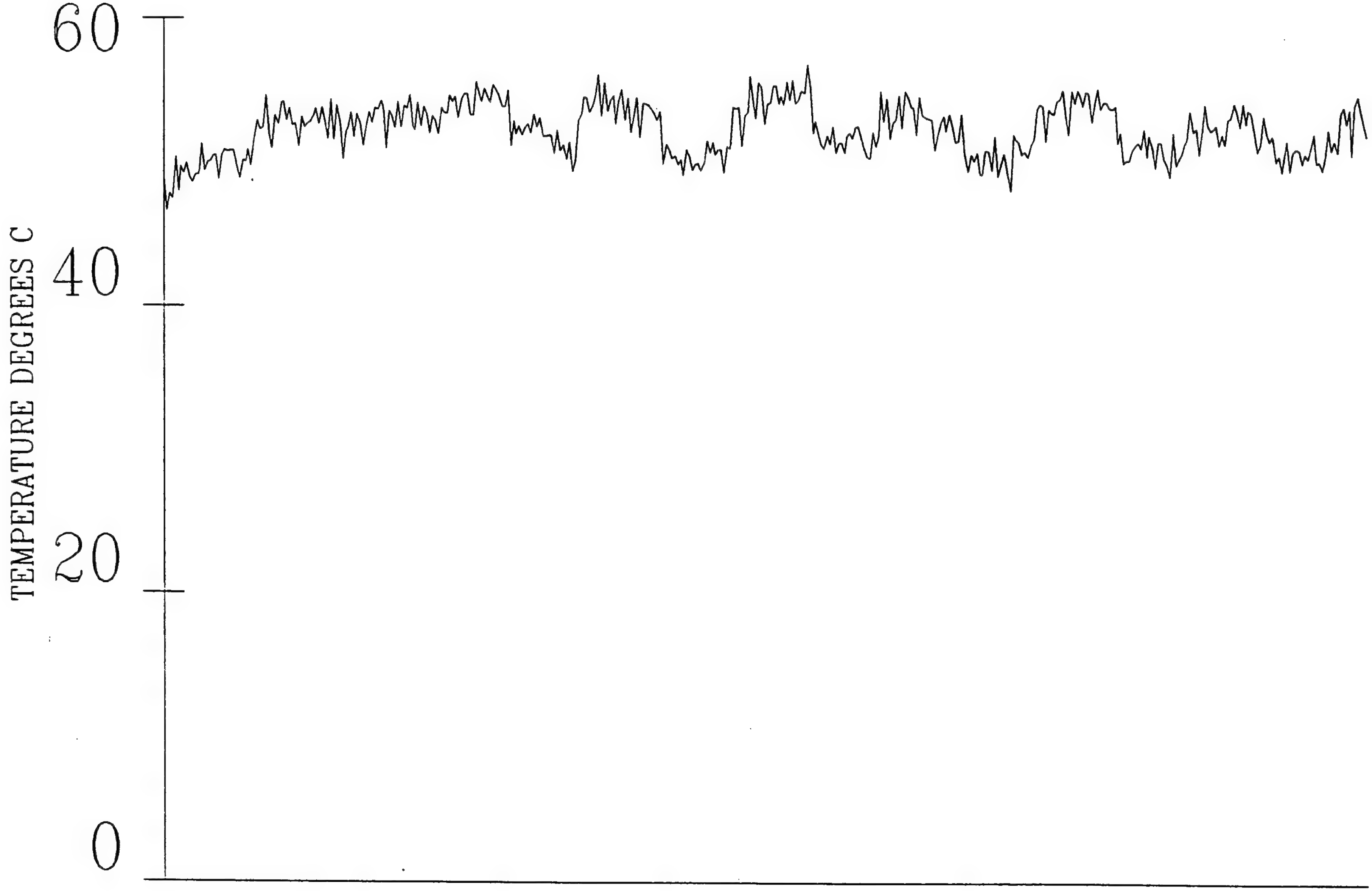
Source code for all test programs is given in Appendix B.

10. APPENDIX

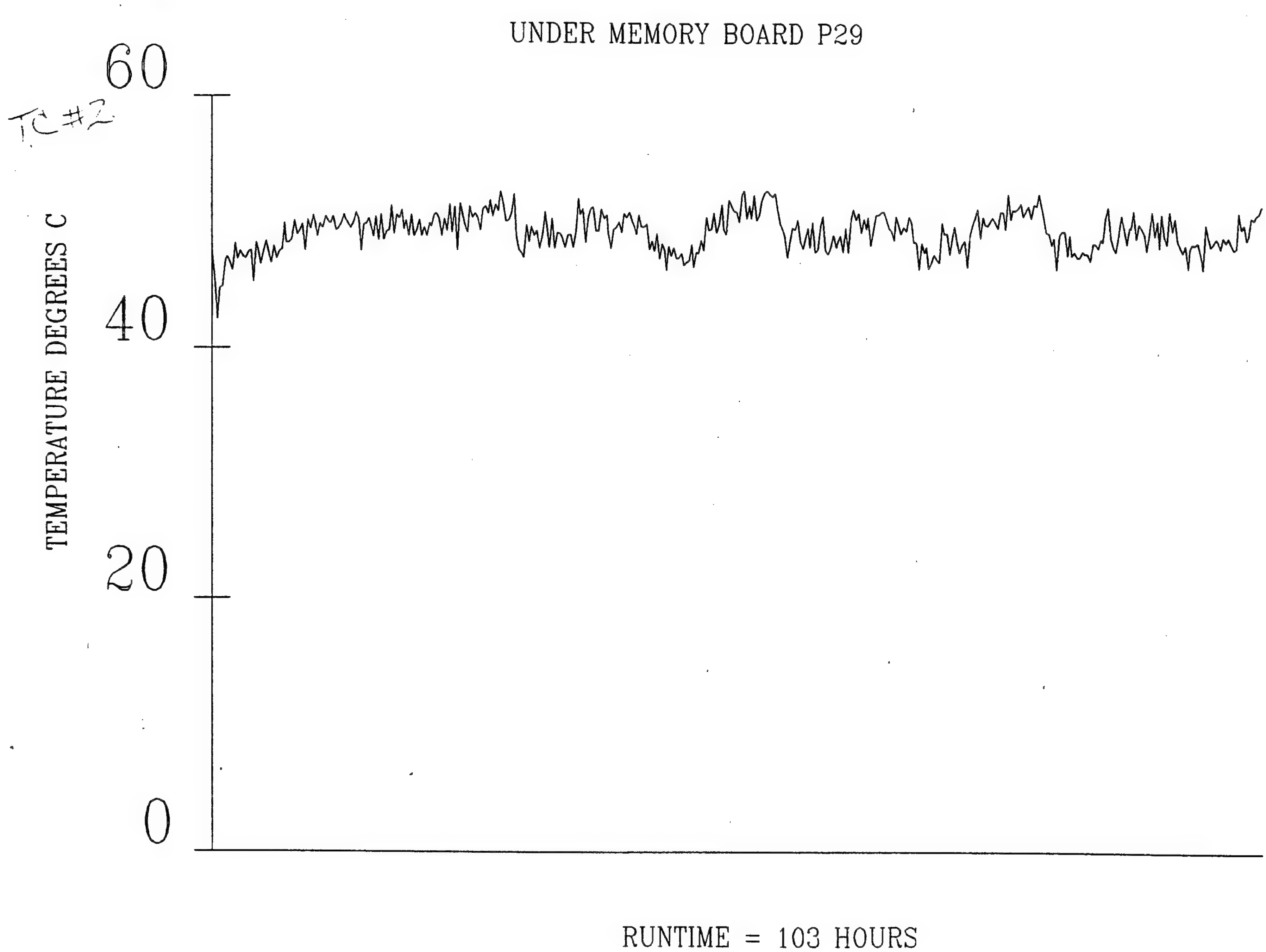
10.1 Appendix A Temperature Profiles

TC #

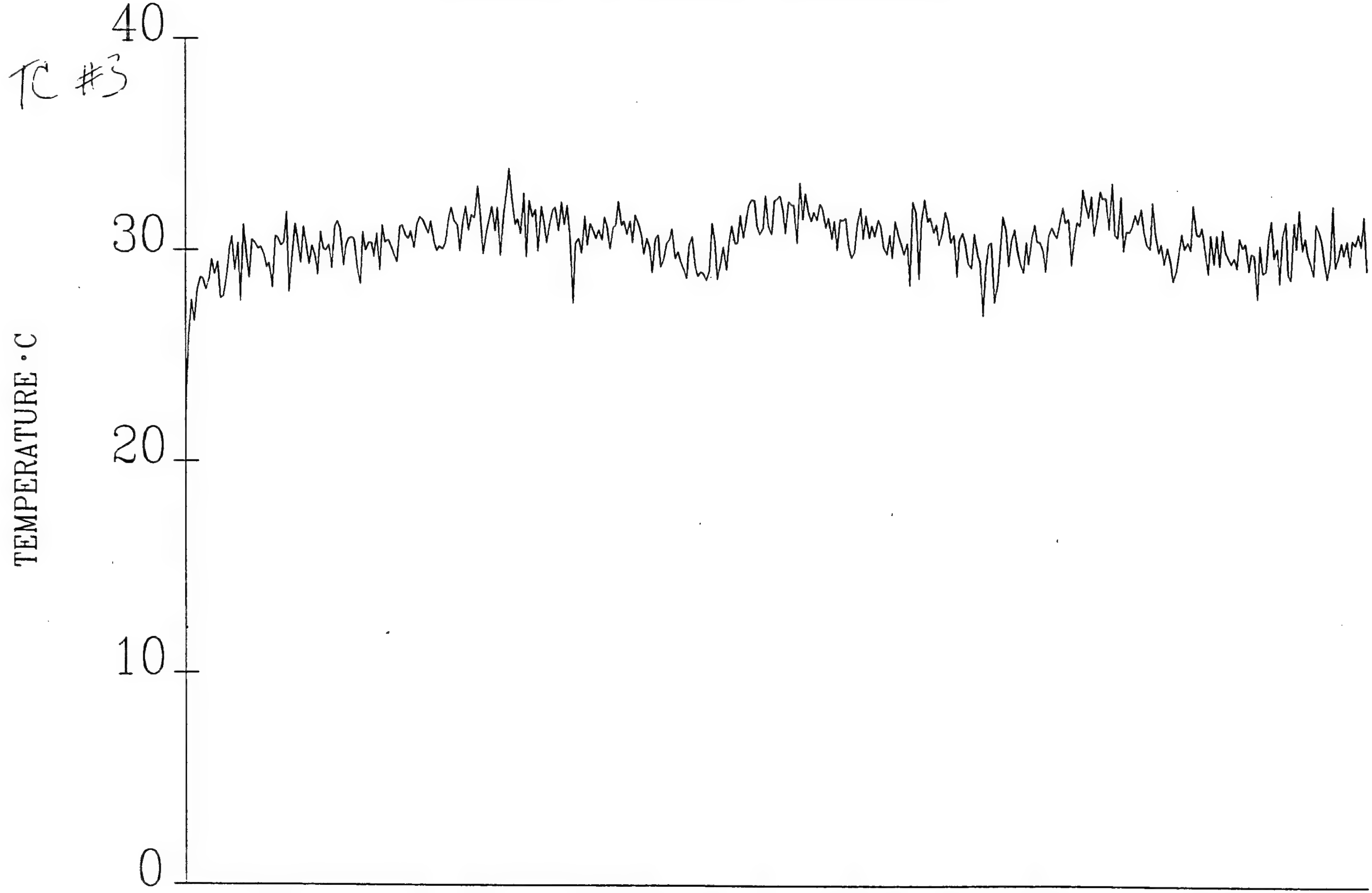
UNDER MEMORY BOARD ON PROCESSOR P31



RUNTIME = 103 HOURS

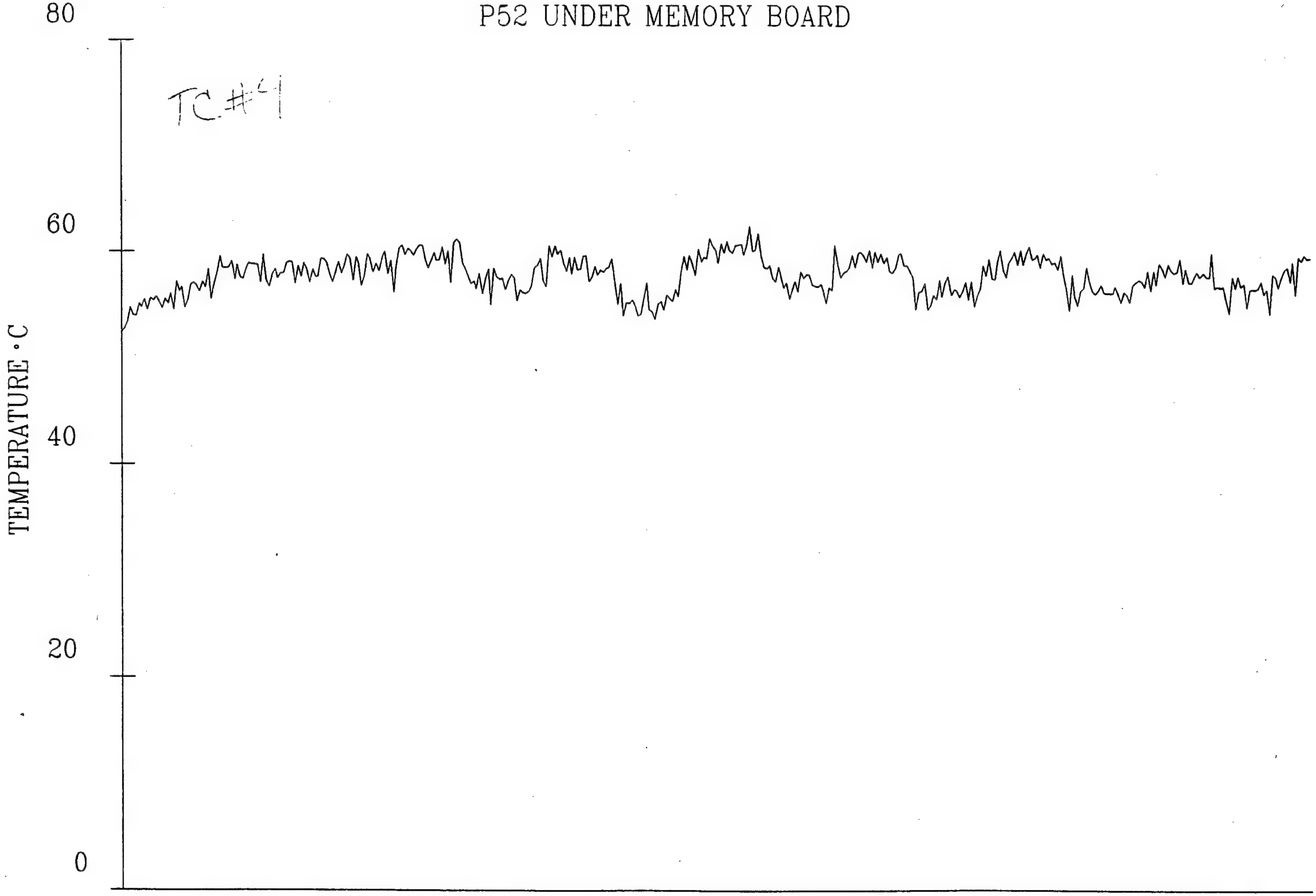

UNDER MEMORY BOARD P29
TC#2
TEMPERATURE DEGREES C
60
40
20
0
RUNTIME = 103 HOURS

LOOSE IN LOWER LEFT CARD CAGE



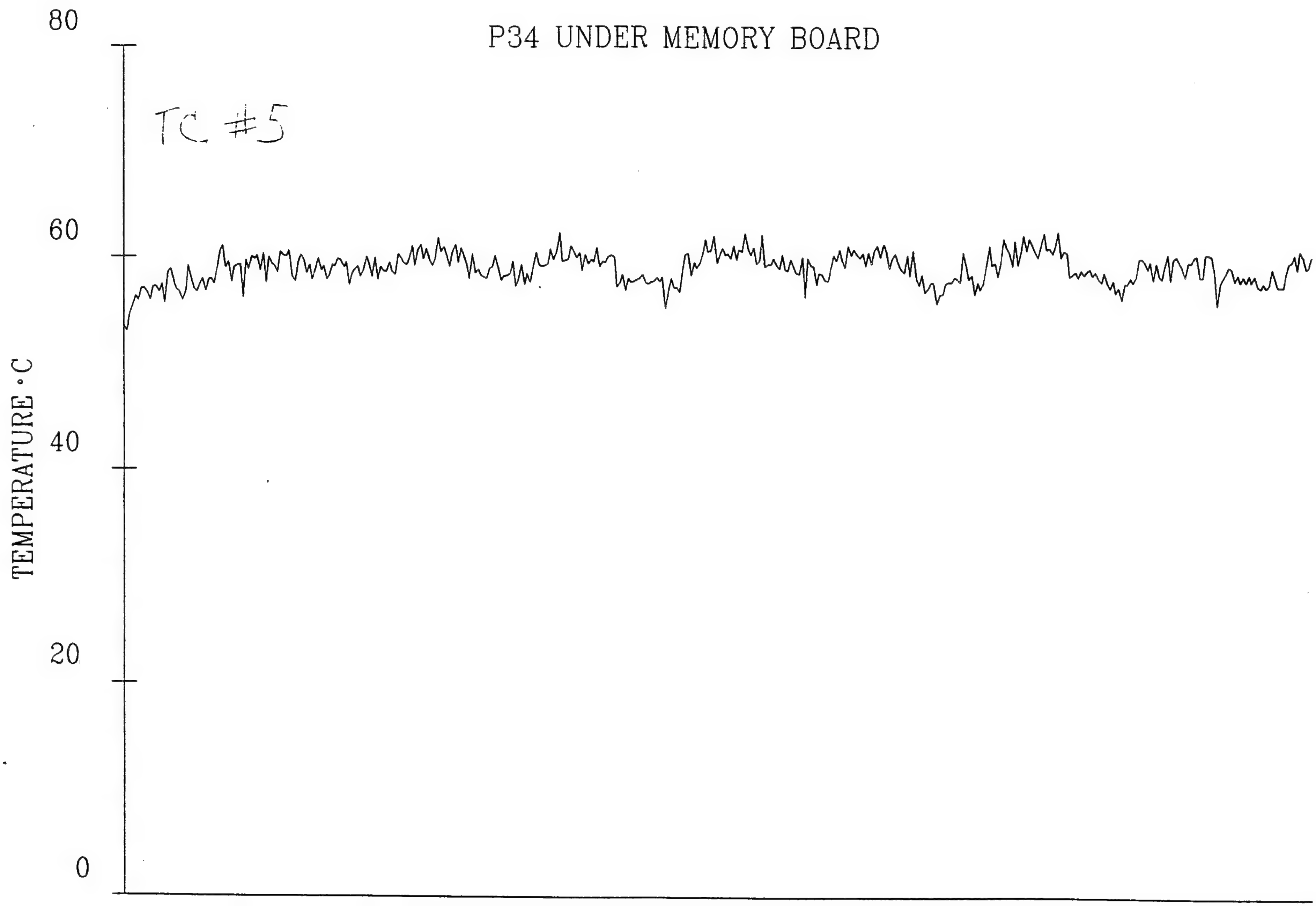
RUNTIME = 103 HOURS

P52 UNDER MEMORY BOARD

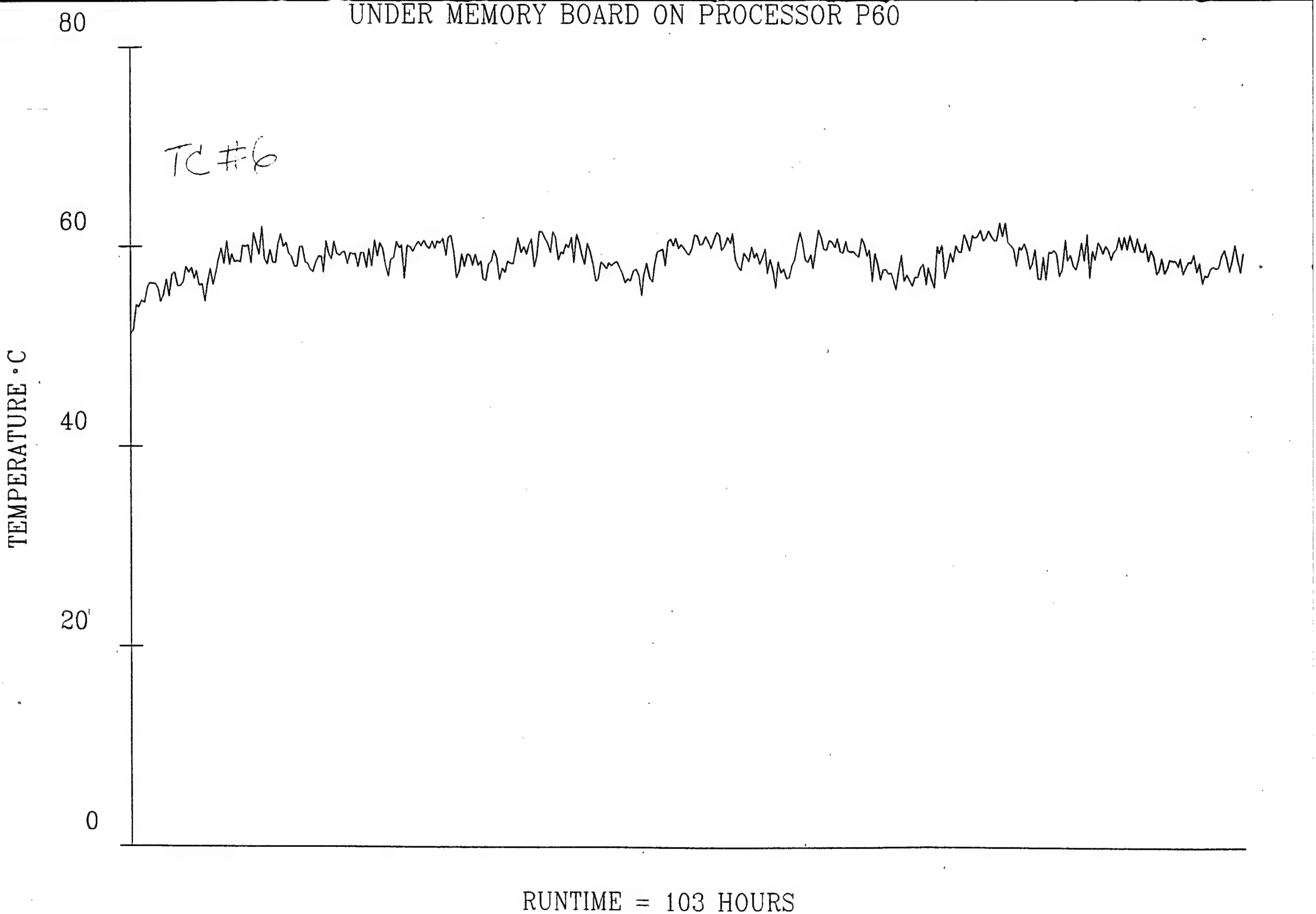


RUNTIME = 103 HOURS

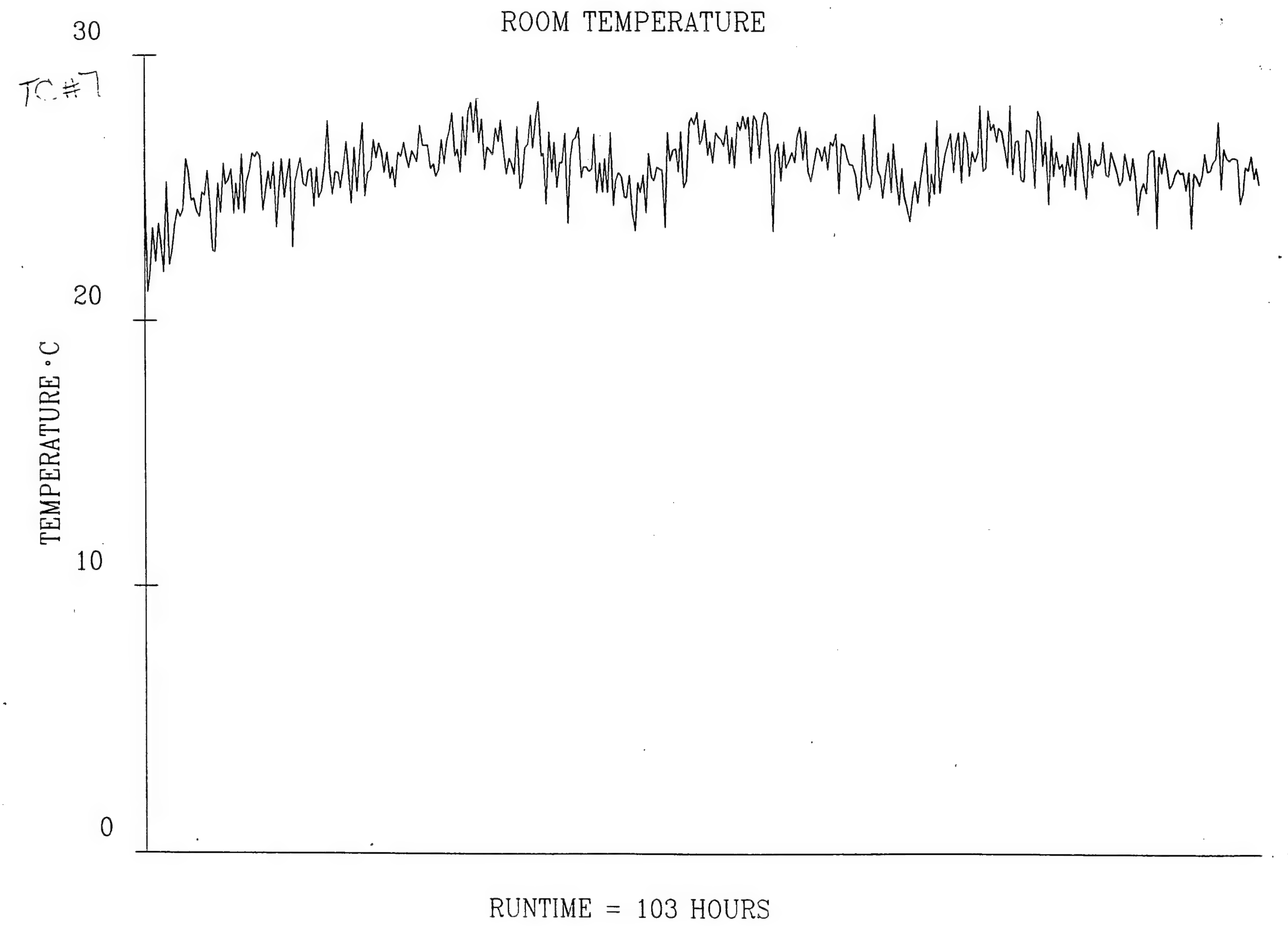
P34 UNDER MEMORY BOARD



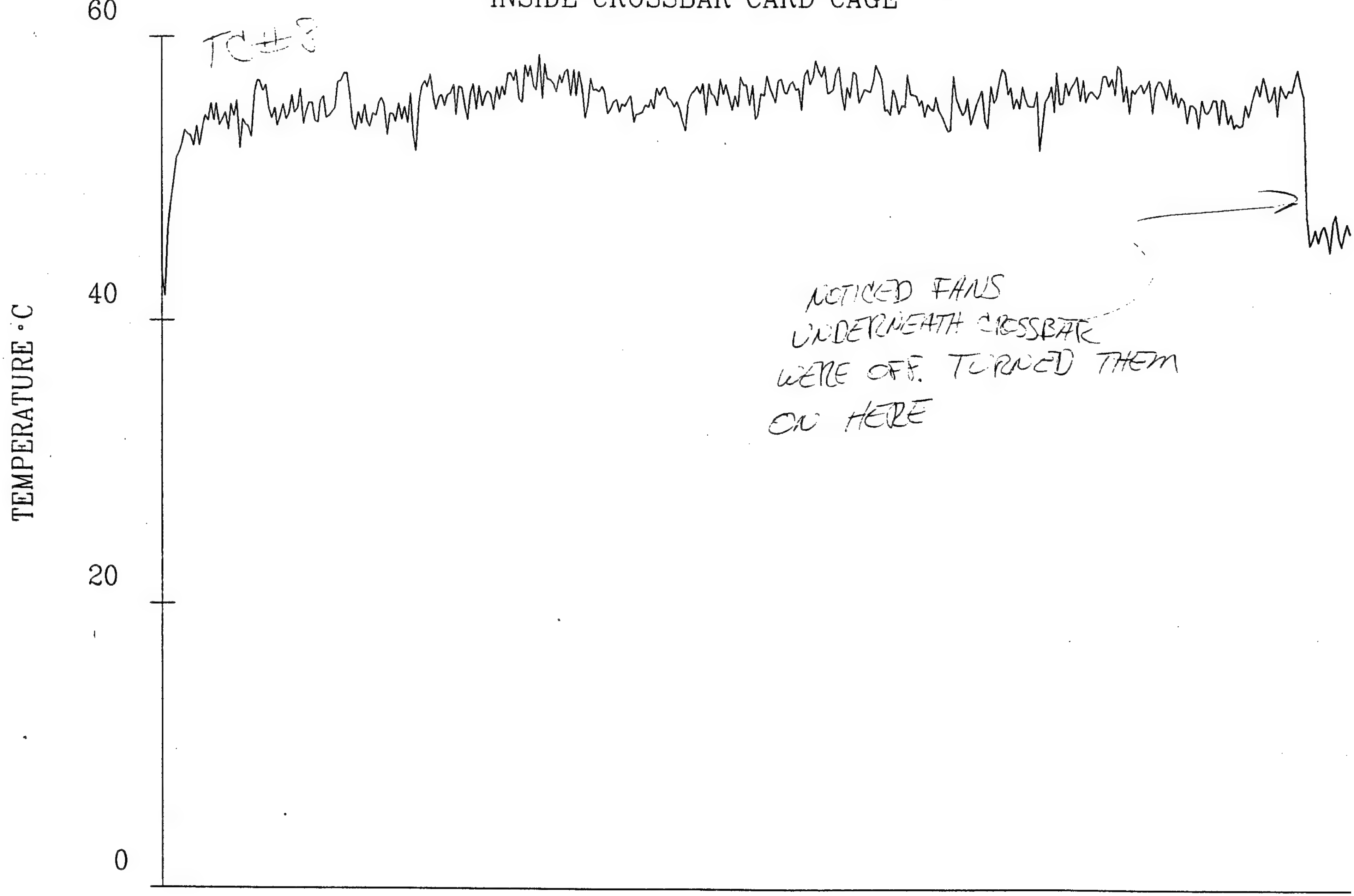
RUNTIME = 103 HOURS



UNDER MEMORY BOARD ON PROCESSOR P60
TC #6
80
60
40
20
0
TEMPERATURE •C
RUNTIME = 103 HOURS

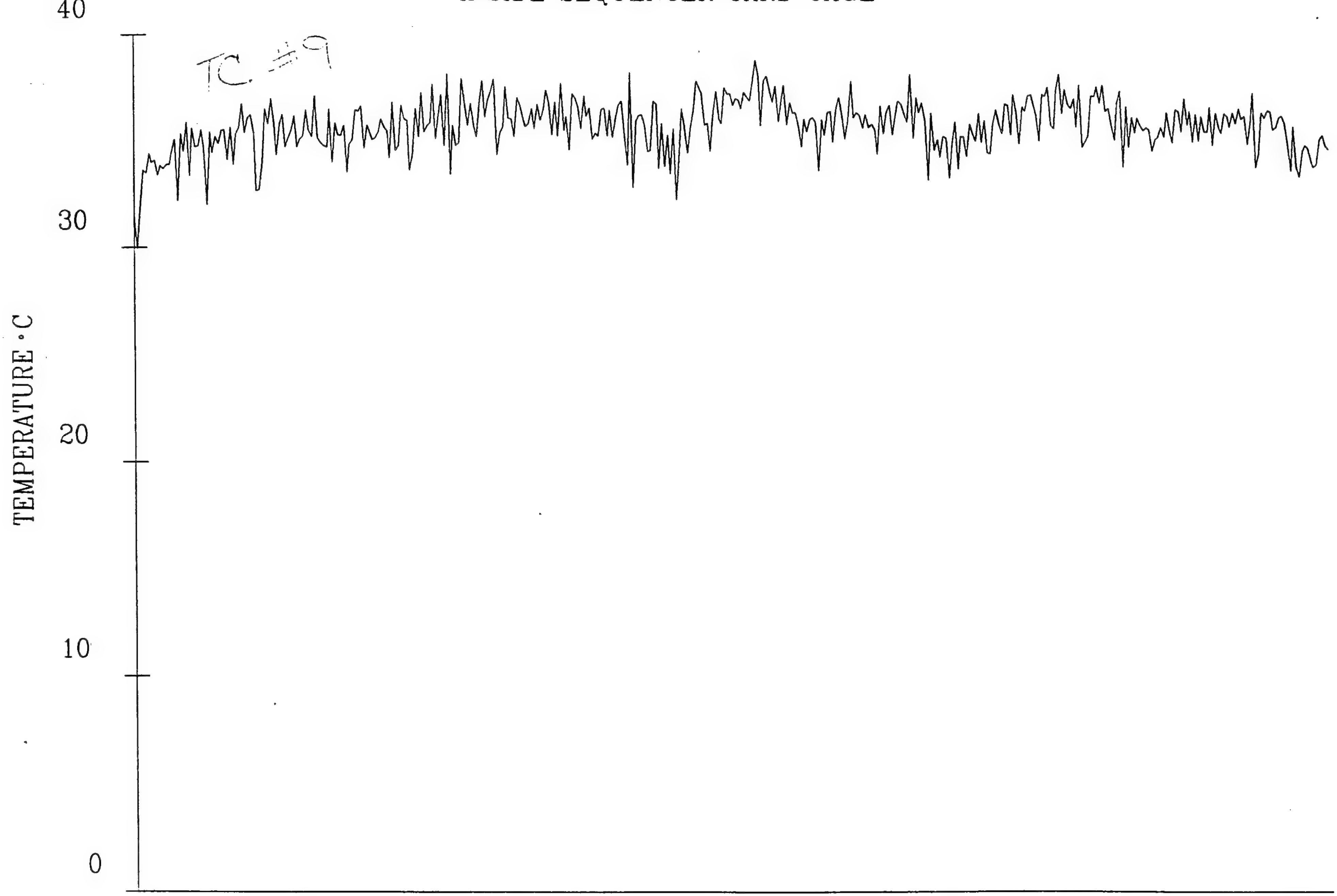

ROOM TEMPERATURE
TC #7
30
20
10
0
TEMPERATURE °C
RUNTIME = 103 HOURS

INSIDE CROSSBAR CARD CAGE



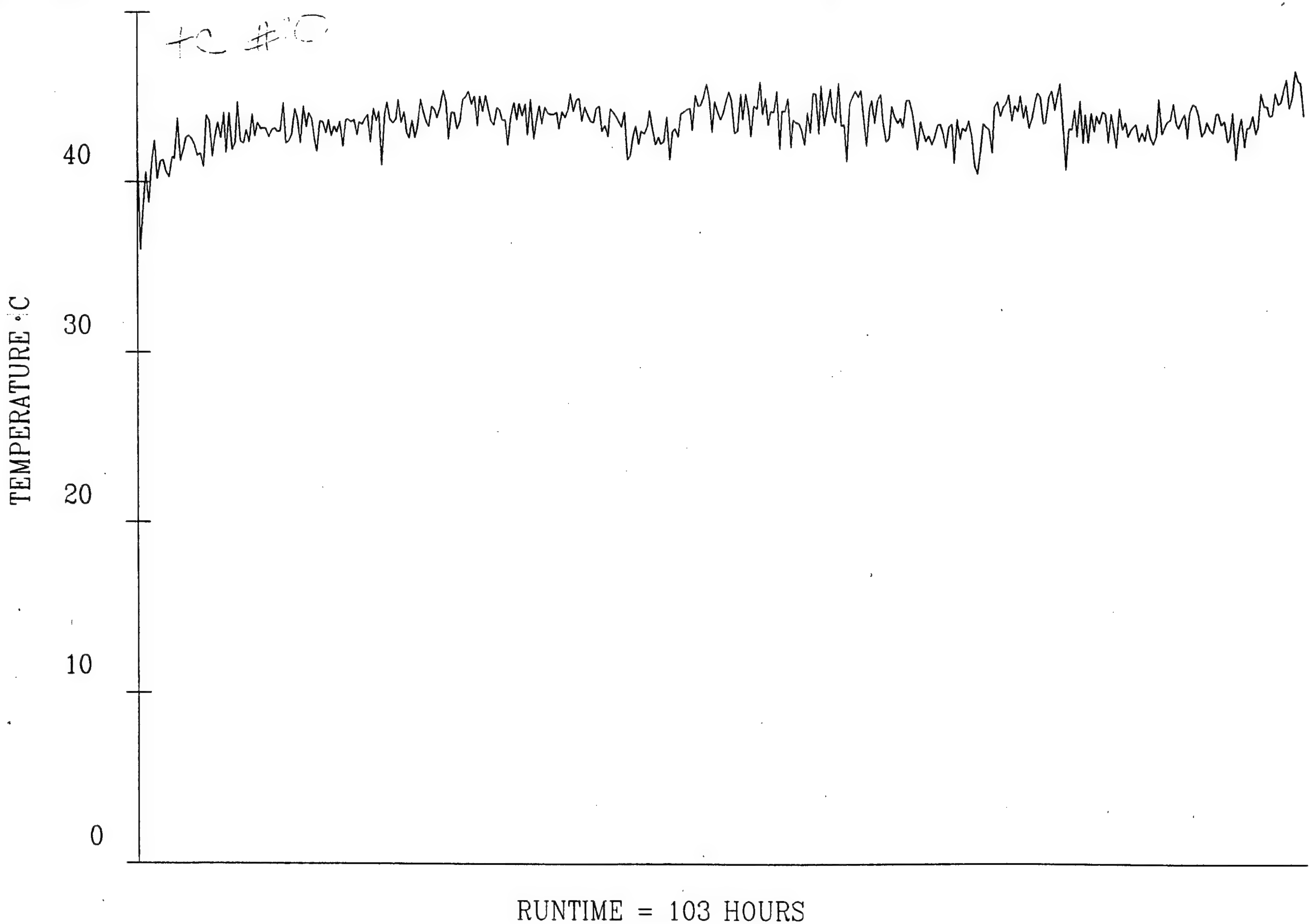
RUNTIME = 103 HOURS

INSIDE SEQUENCER CARD CAGE

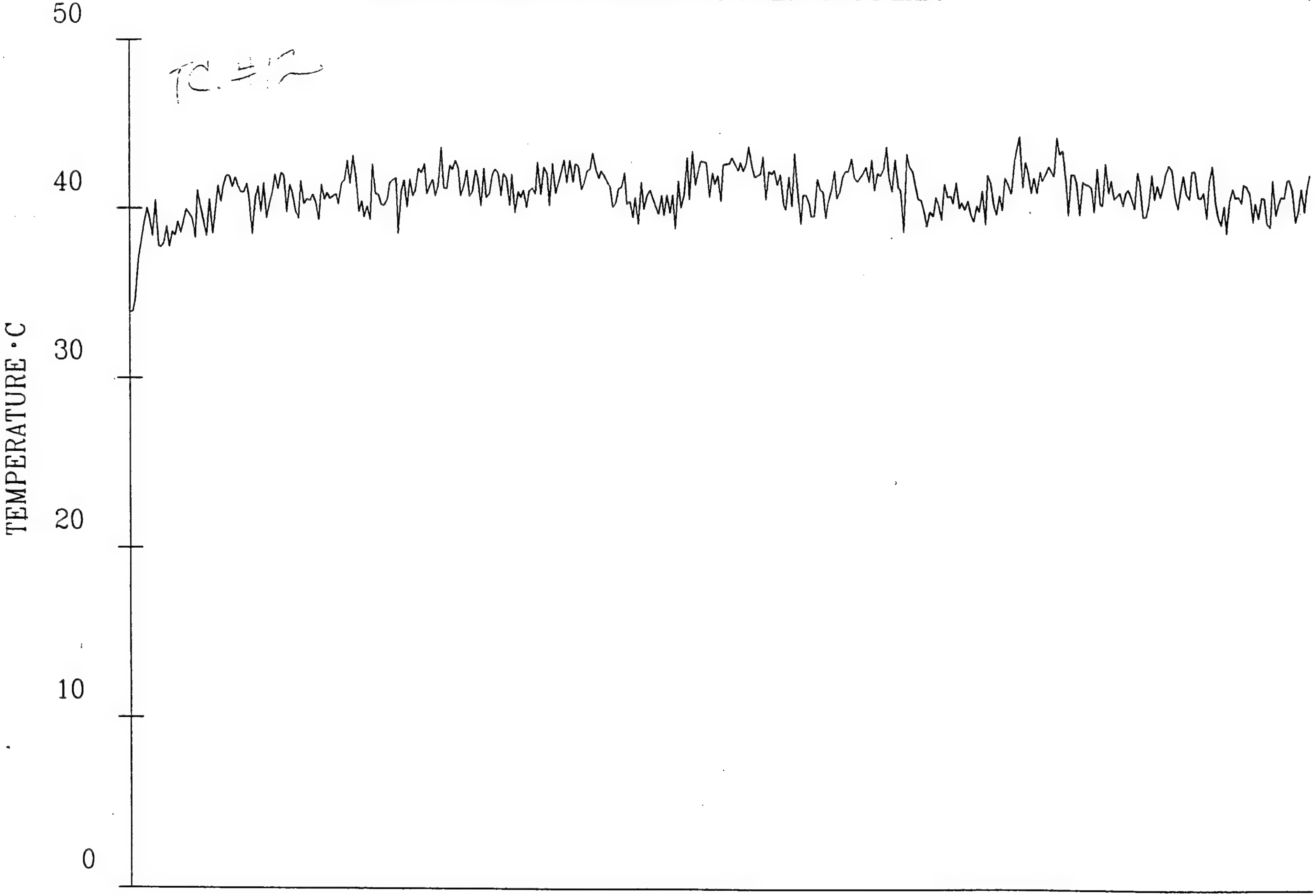


RUNTIME = 103 HOURS

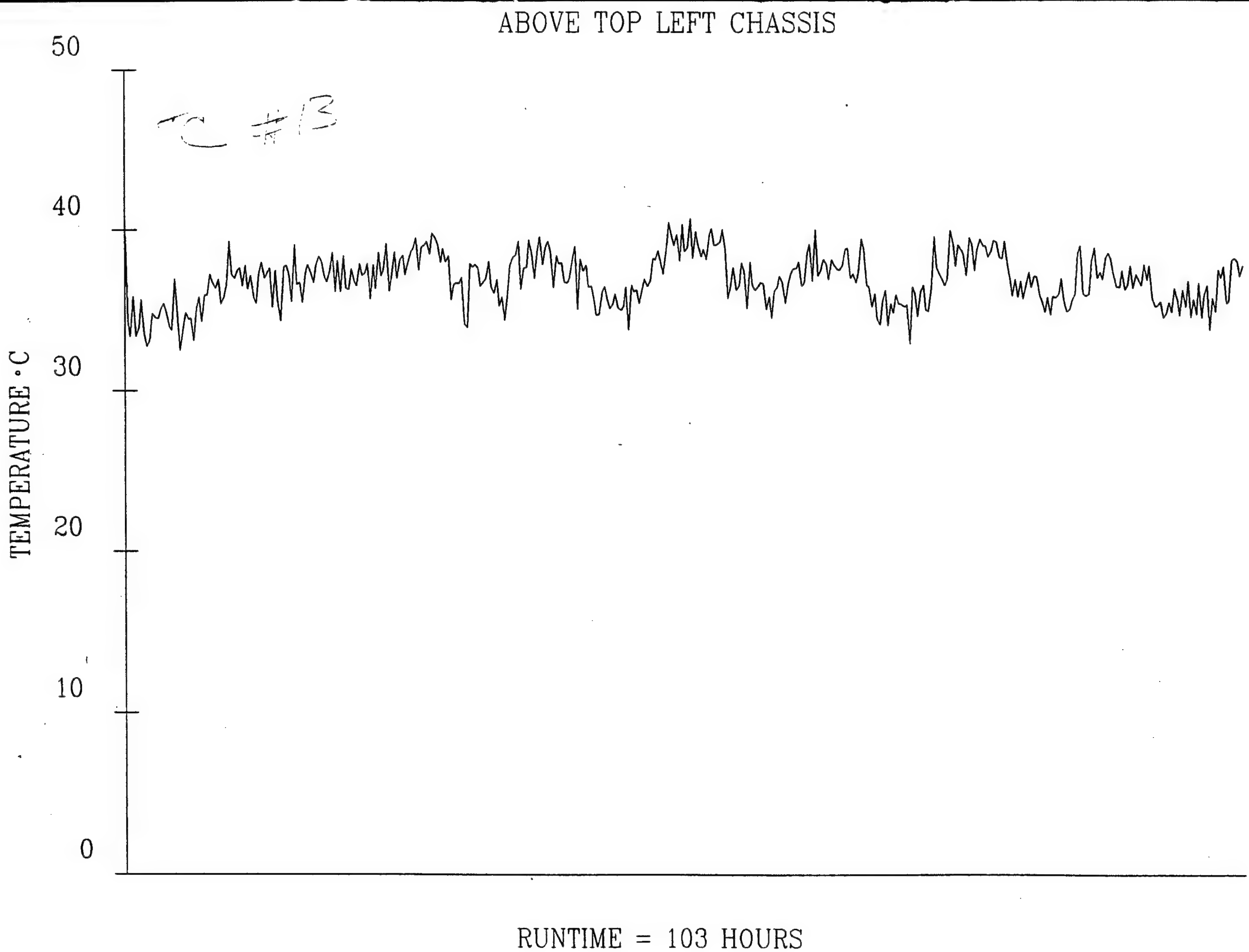
ON CROSSBAR STATUS DISPLAY



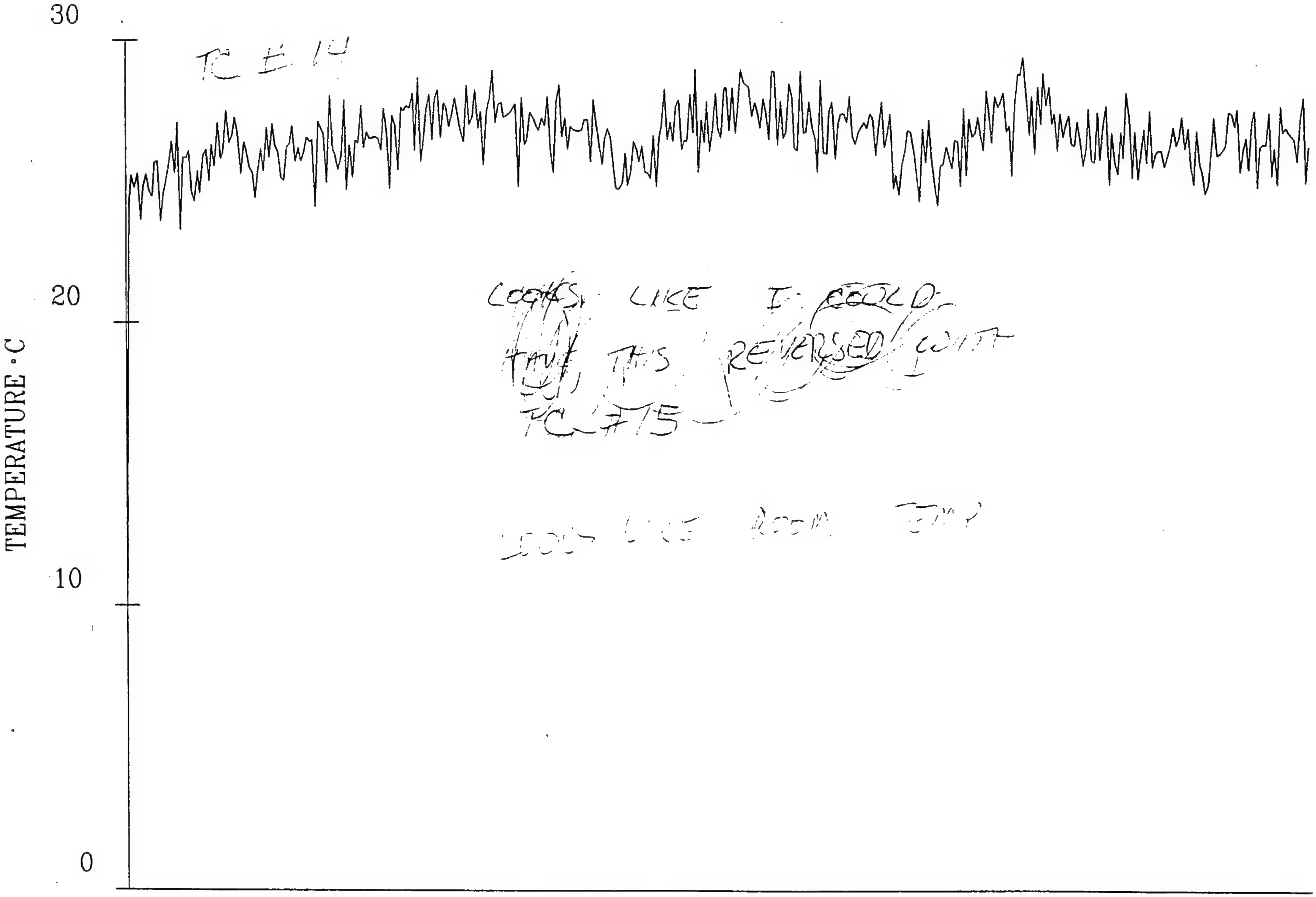
REAR OF RIGHT CABINET POWER SUPPLIES



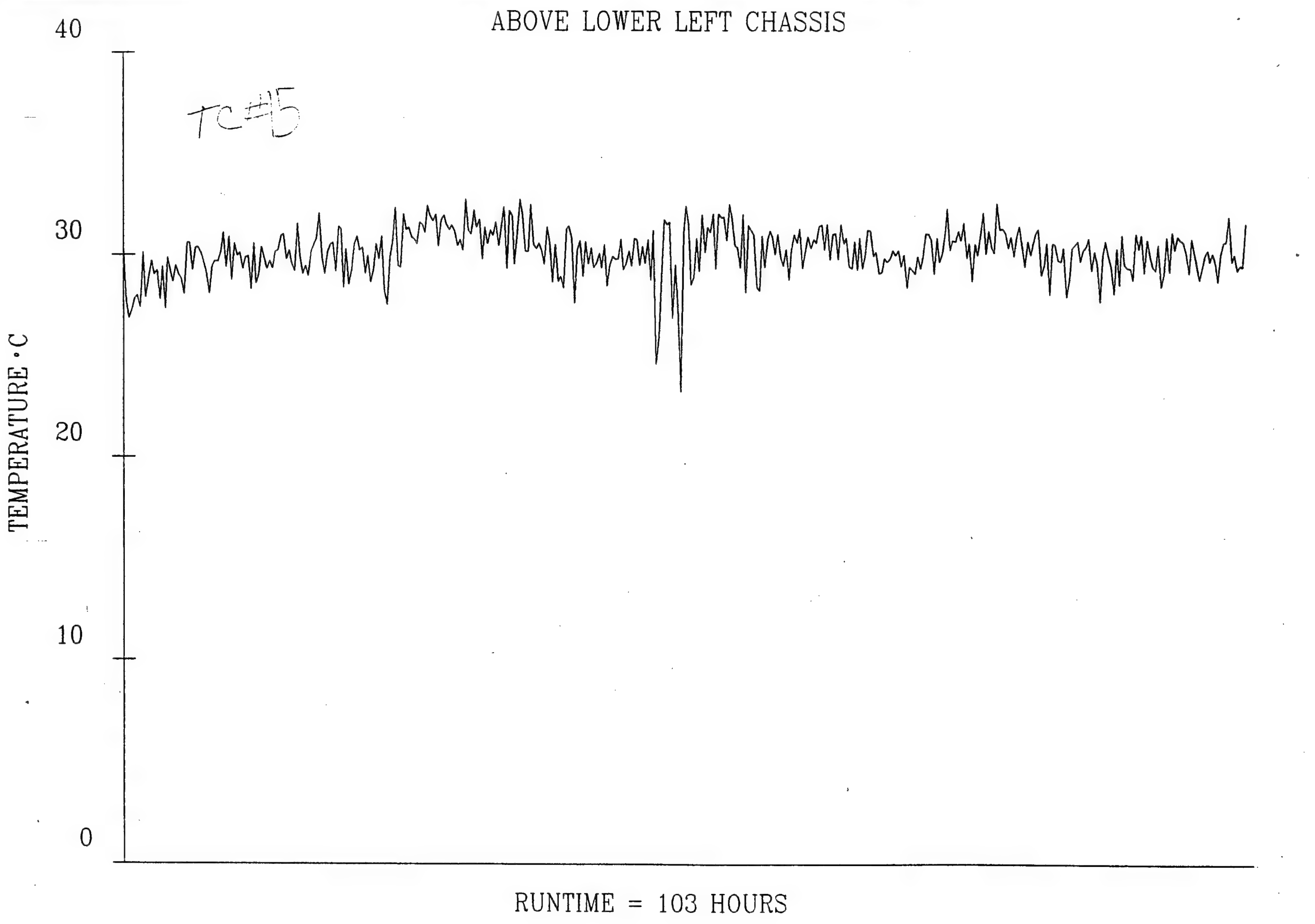
RUNTIME = 103 HOURS


ABOVE TOP LEFT CHASSIS
TC #13
TEMPERATURE • C
50
40
30
20
10
0
RUNTIME = 103 HOURS

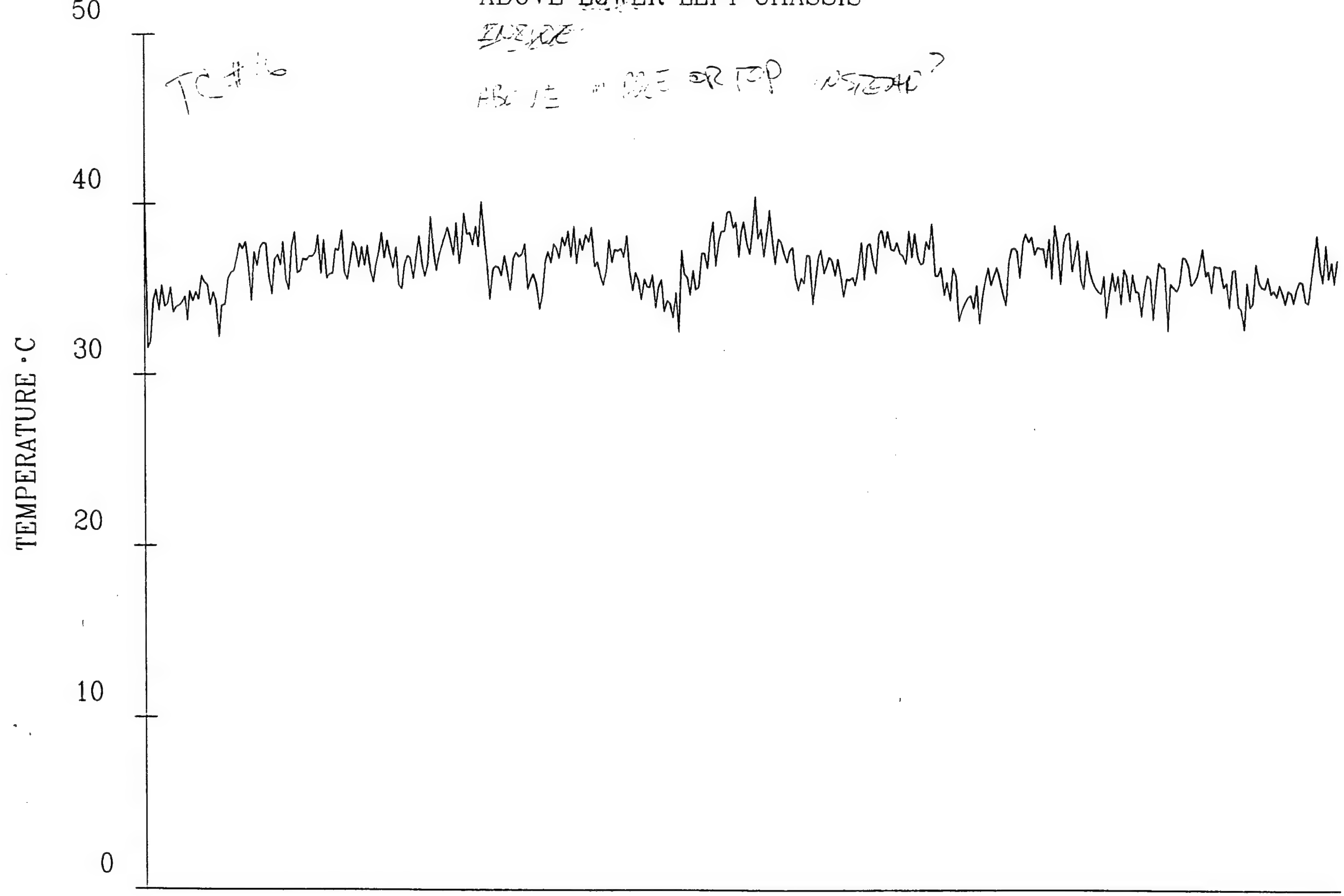
ABOVE MIDDLE LEFT CHASSIS



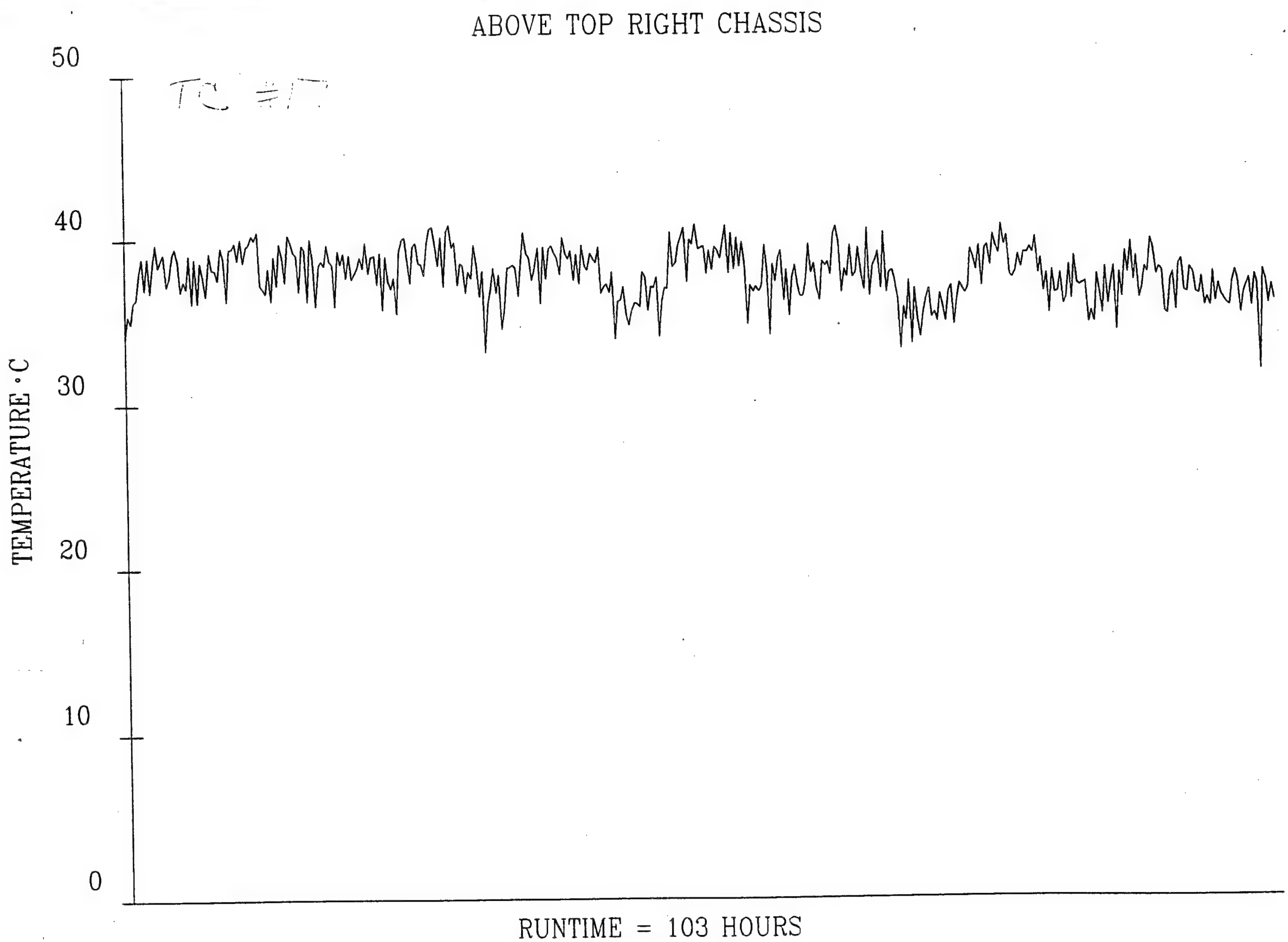
RUNTIME = 103 HOURS


ABOVE LOWER LEFT CHASSIS
TC#5
TEMPERATURE •C
40
30
20
10
0
RUNTIME = 103 HOURS

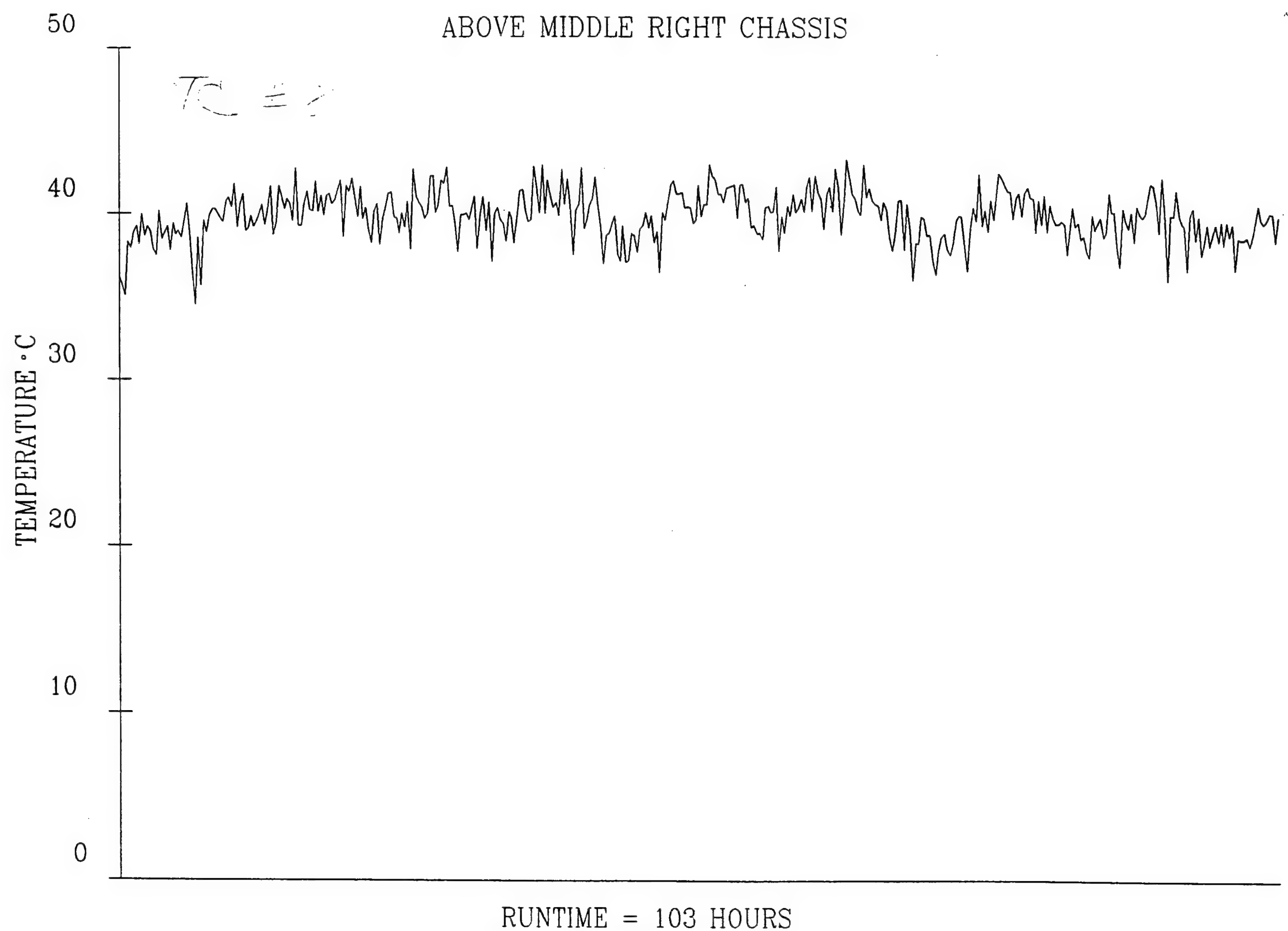
~~ABOVE~~ LOWER LEFT CHASSIS

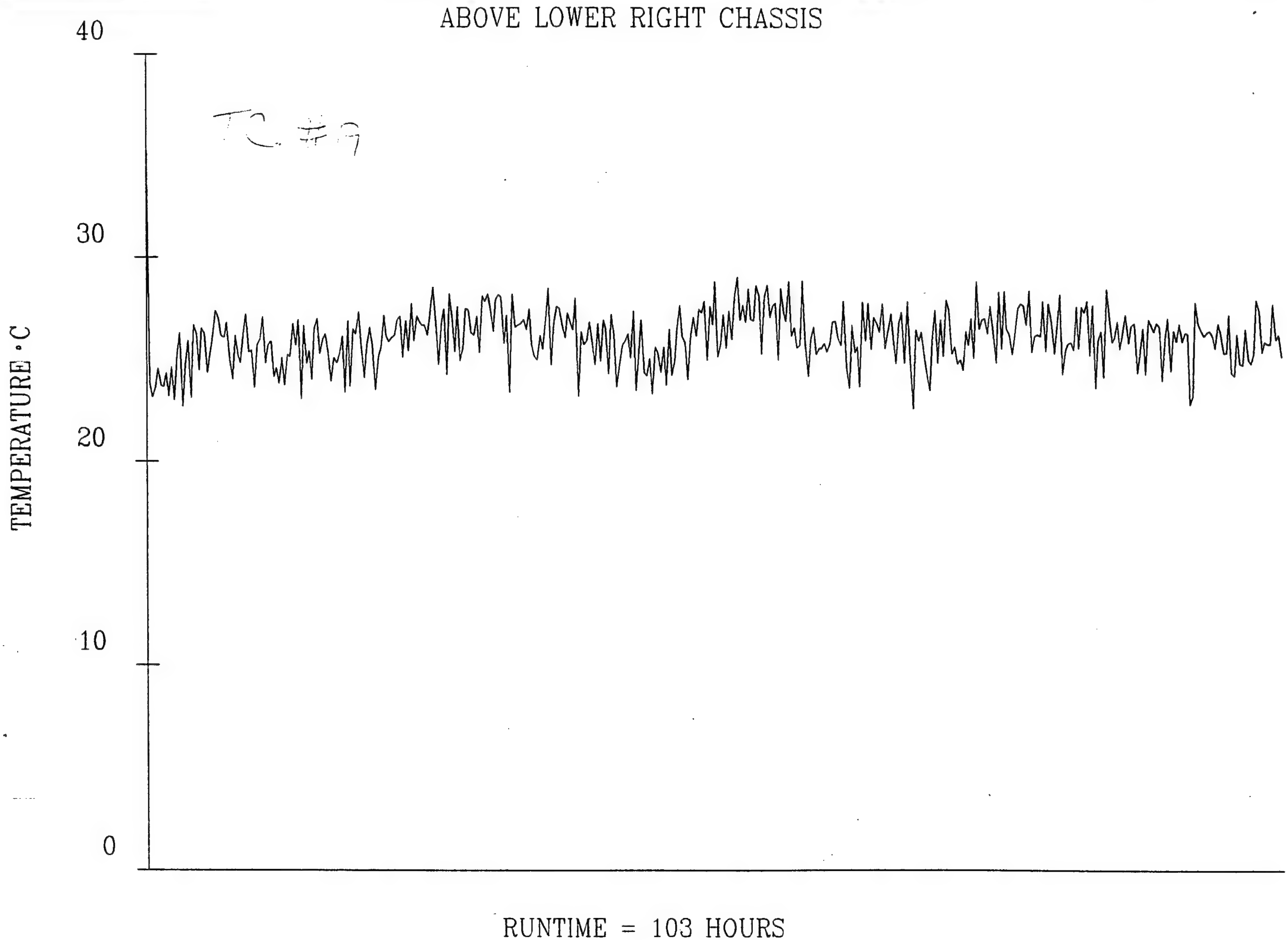


RUNTIME = 103 HOURS

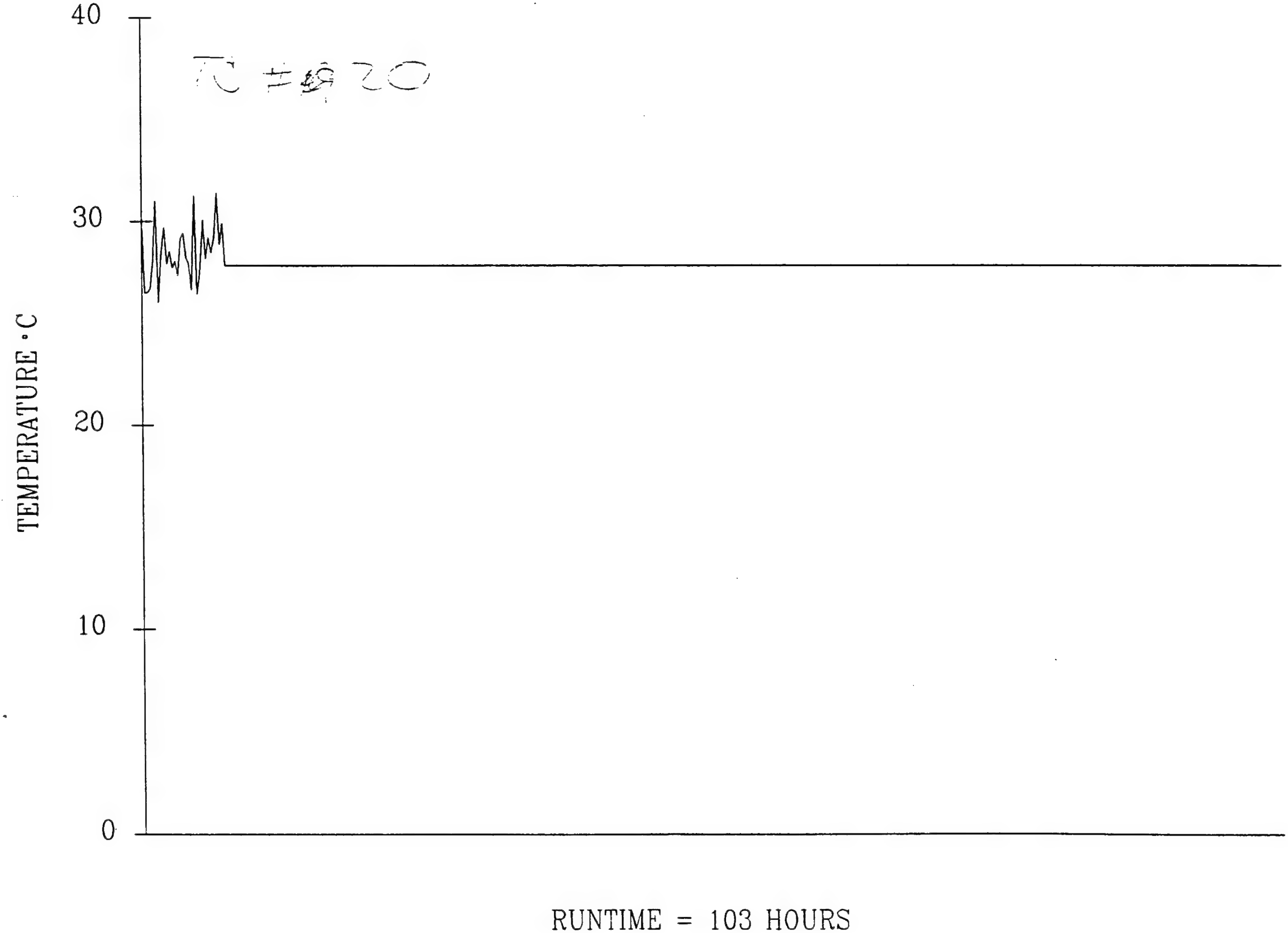


ABOVE TOP RIGHT CHASSIS
TC #17
50
40
30
20
10
0
TEMPERATURE • C
RUNTIME = 103 HOURS

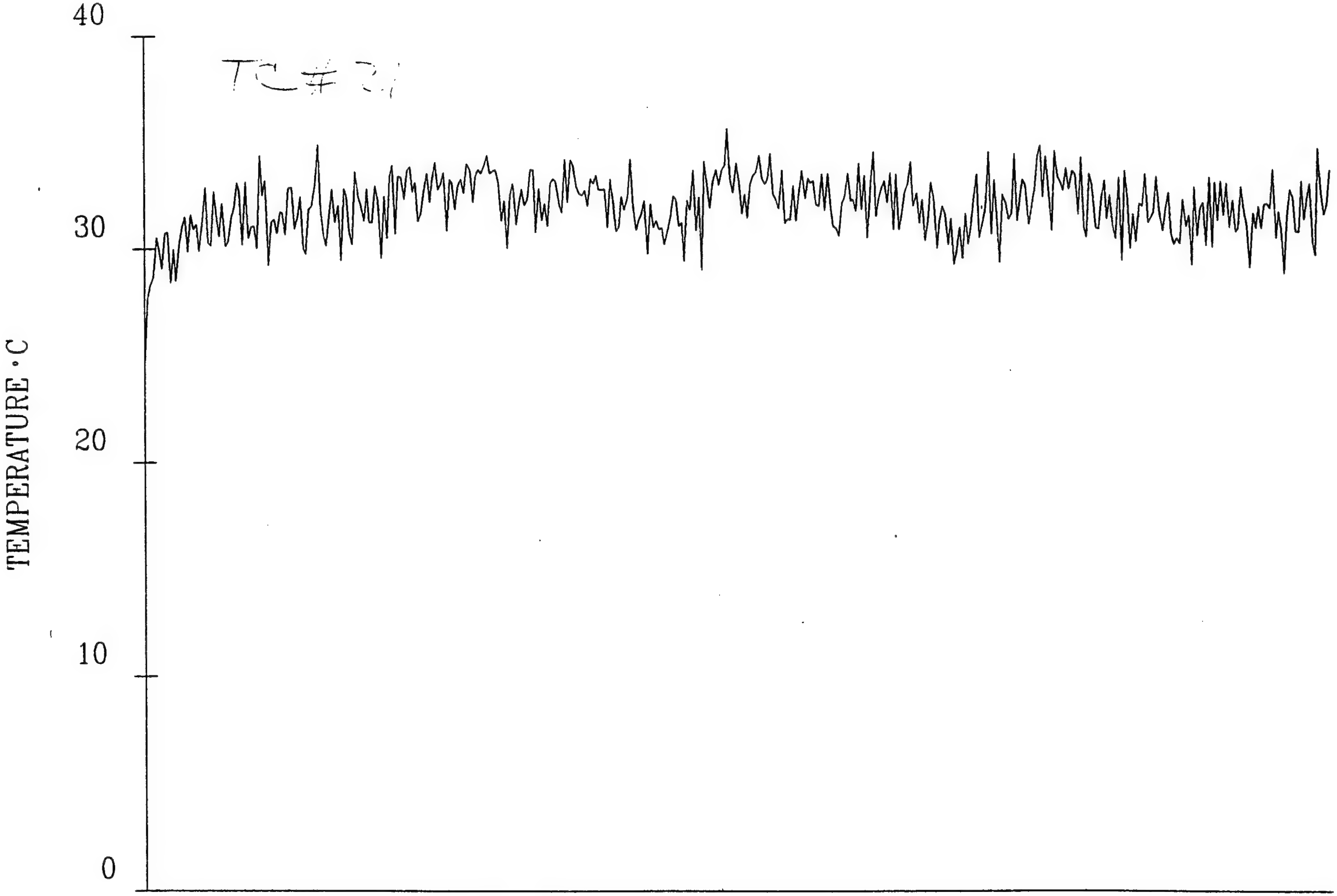

ABOVE MIDDLE RIGHT CHASSIS
TC #?
50
40
30
20
10
0
TEMPERATURE •C
RUNTIME = 103 HOURS


ABOVE LOWER RIGHT CHASSIS
TC #9
40
30
20
10
0
TEMPERATURE •C
RUNTIME = 103 HOURS

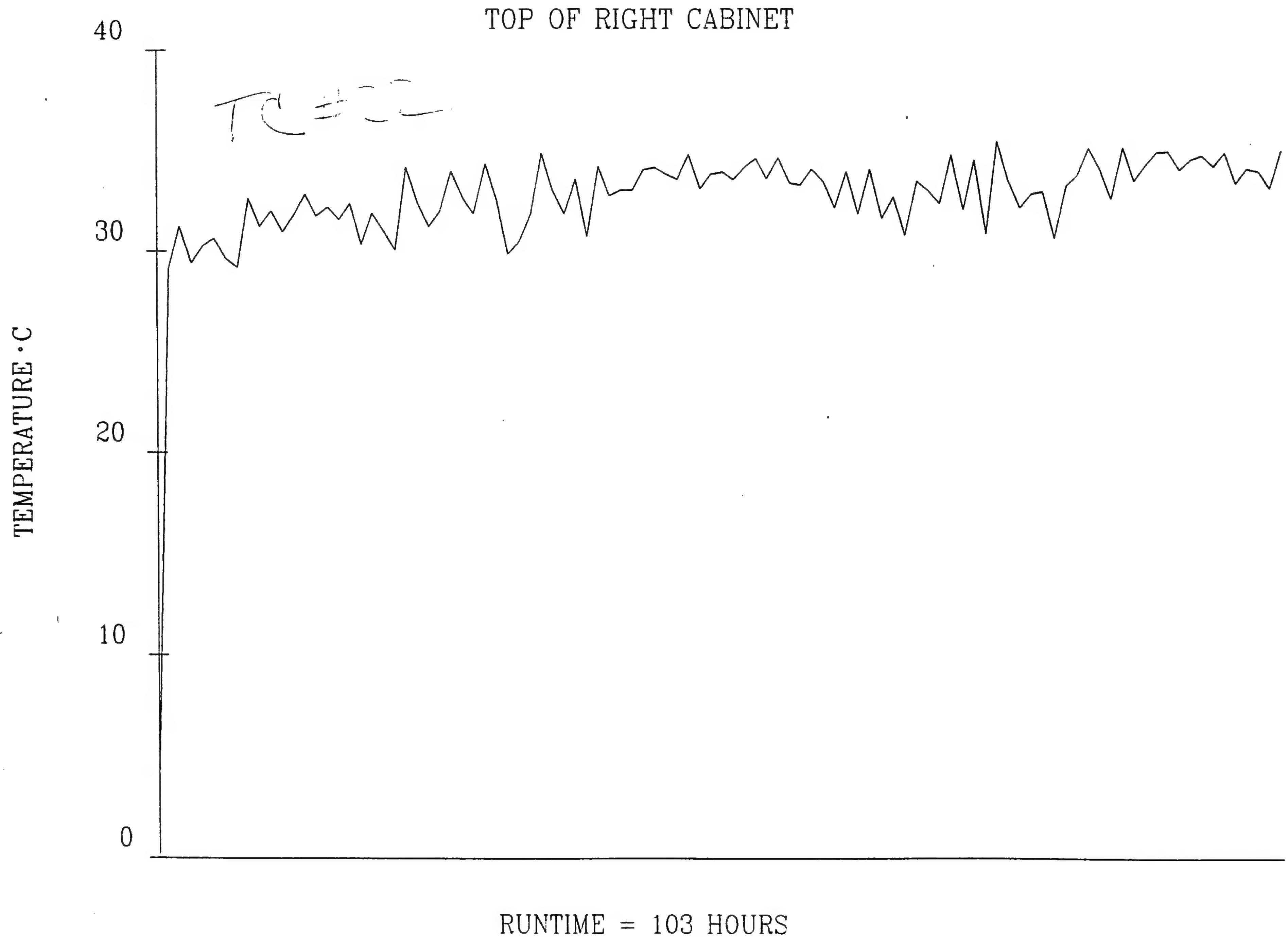
TOP OF LEFT CABINET



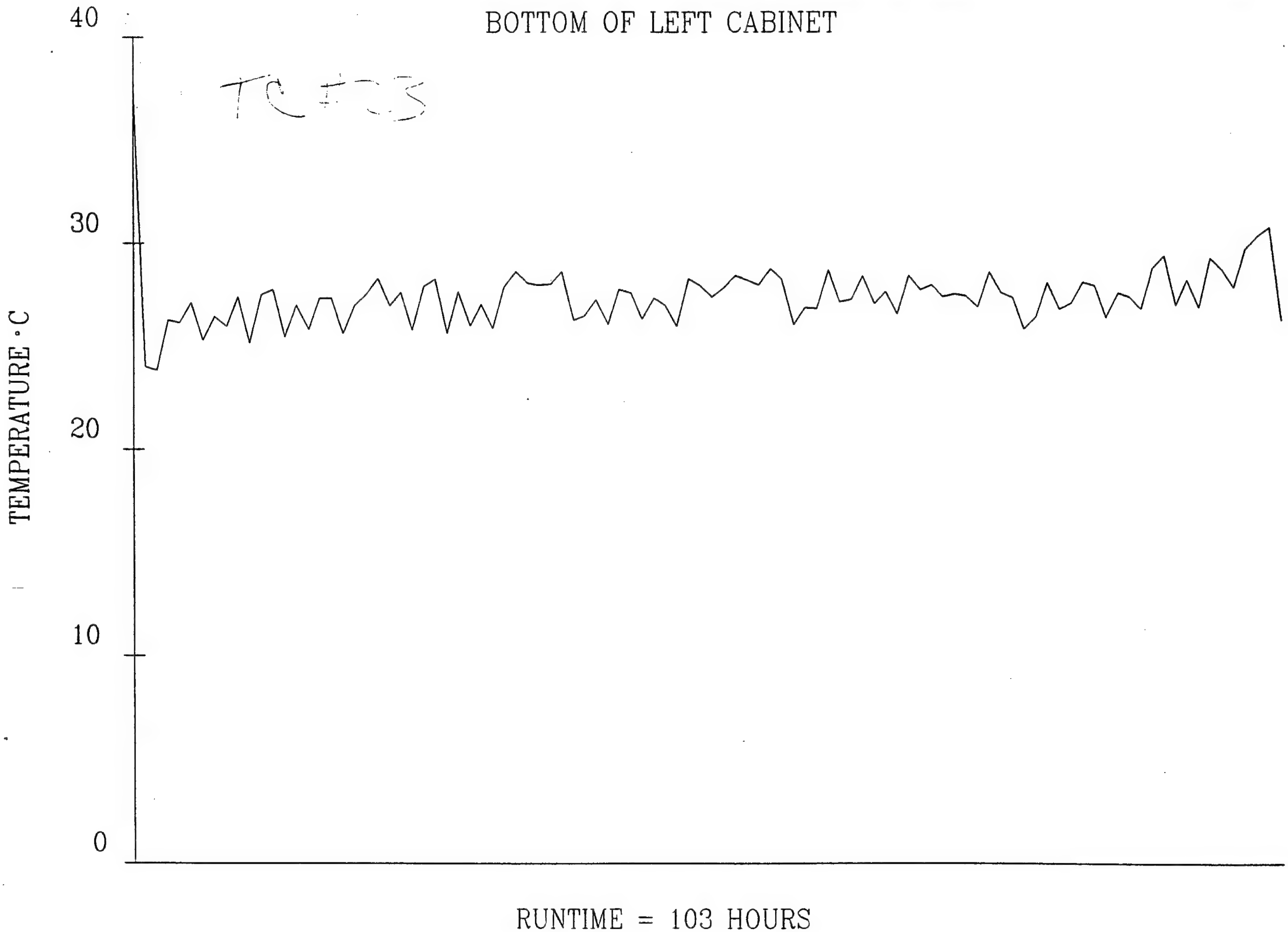
TOP OF MIDDLE CABINET

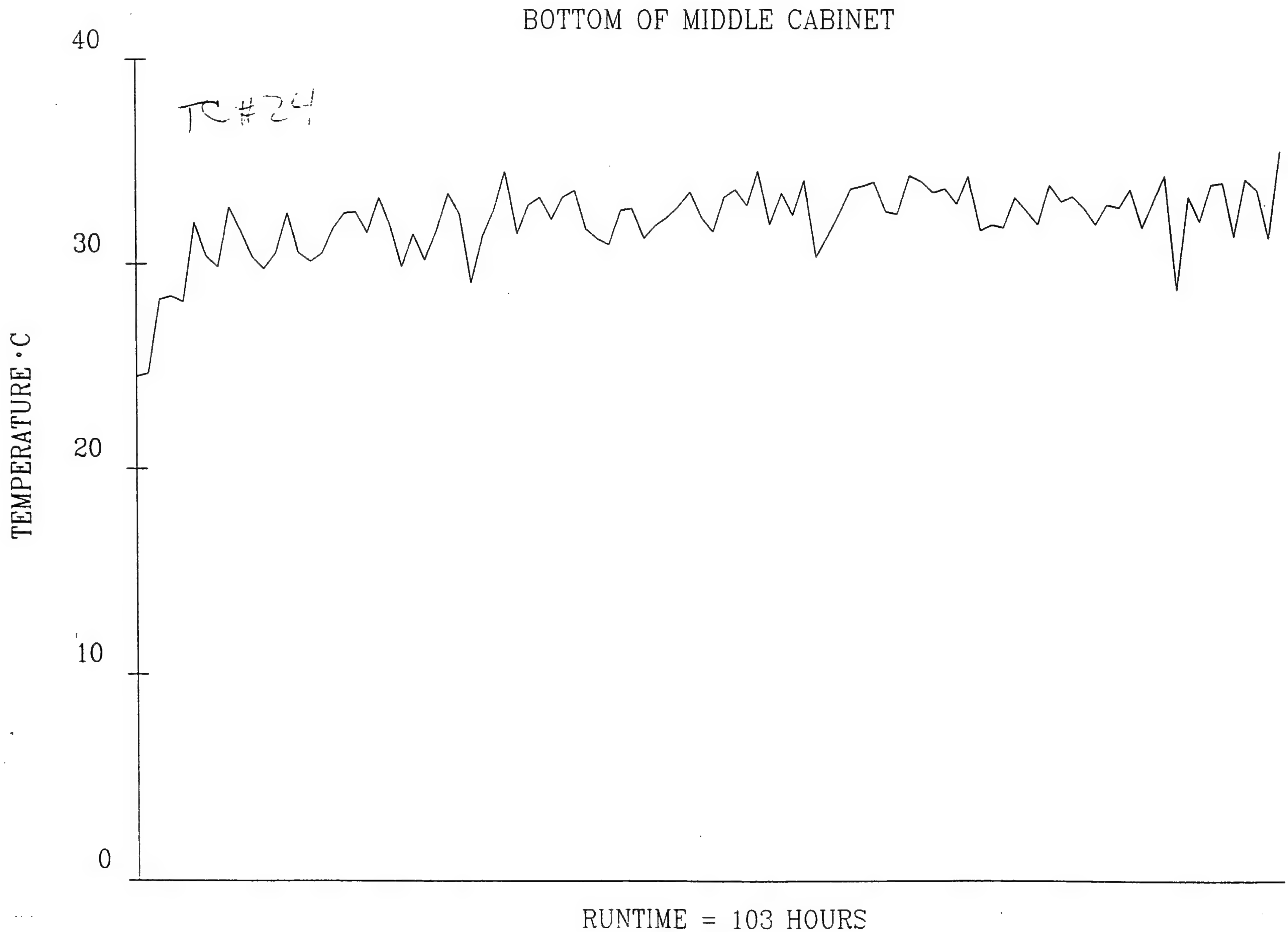


RUNTIME = 103 HOURS

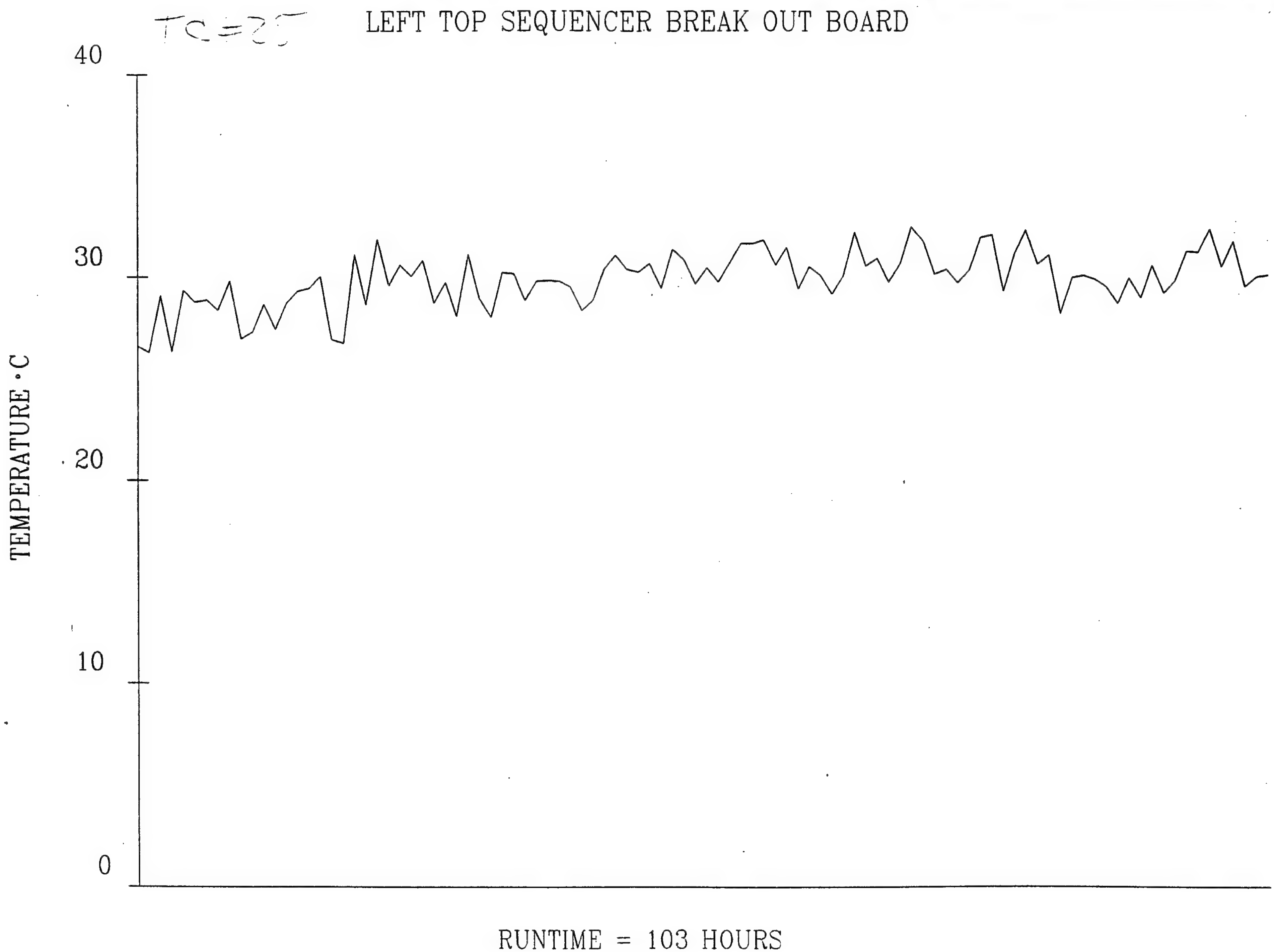


TOP OF RIGHT CABINET
TC #22
40
30
20
10
0
TEMPERATURE ·C
RUNTIME = 103 HOURS

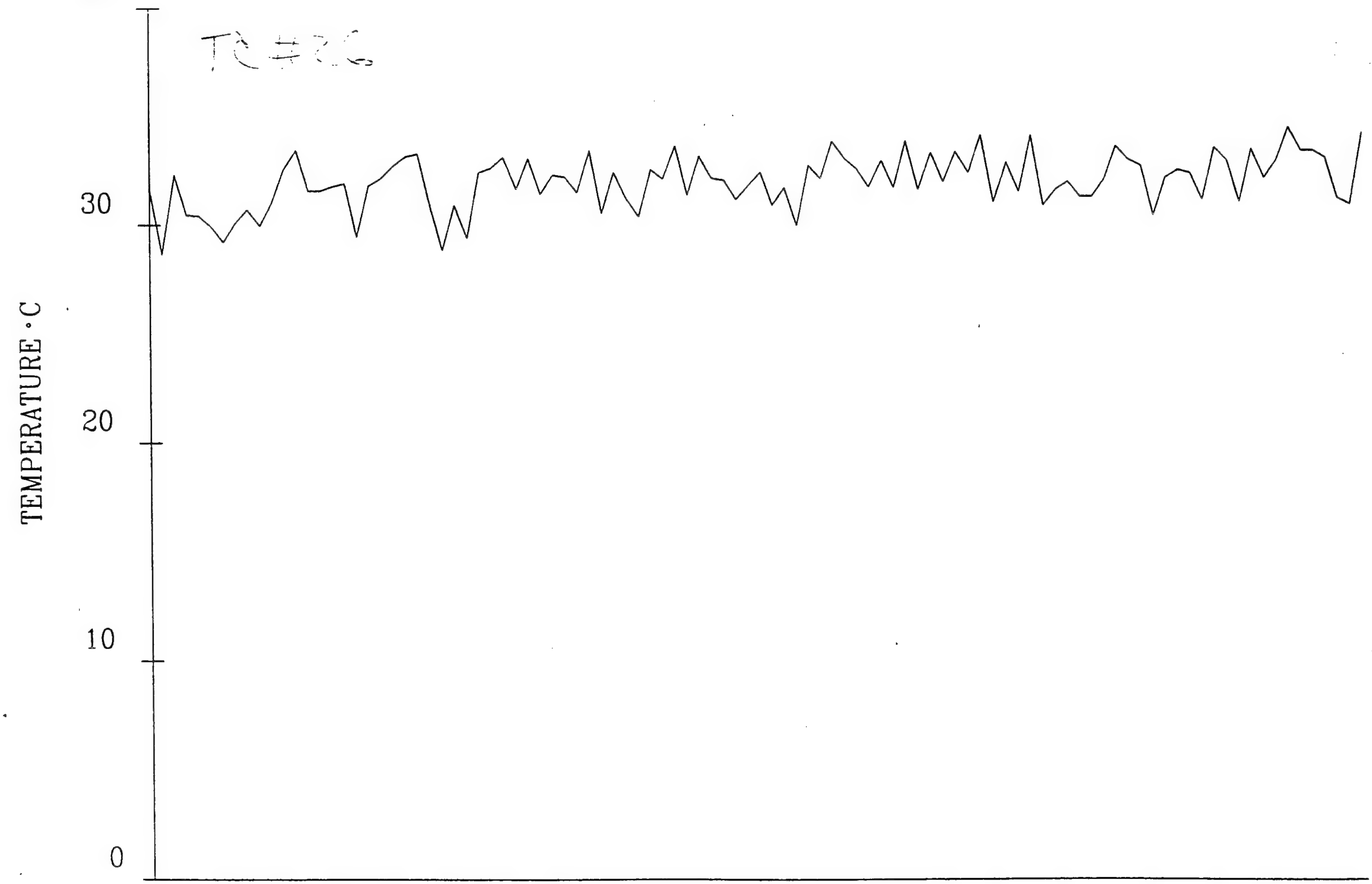

BOTTOM OF LEFT CABINET
TC#23
40
30
20
10
0
TEMPERATURE ·C
RUNTIME = 103 HOURS


BOTTOM OF MIDDLE CABINET
TC #24
40
30
20
10
0
TEMPERATURE •C
RUNTIME = 103 HOURS

TC=25

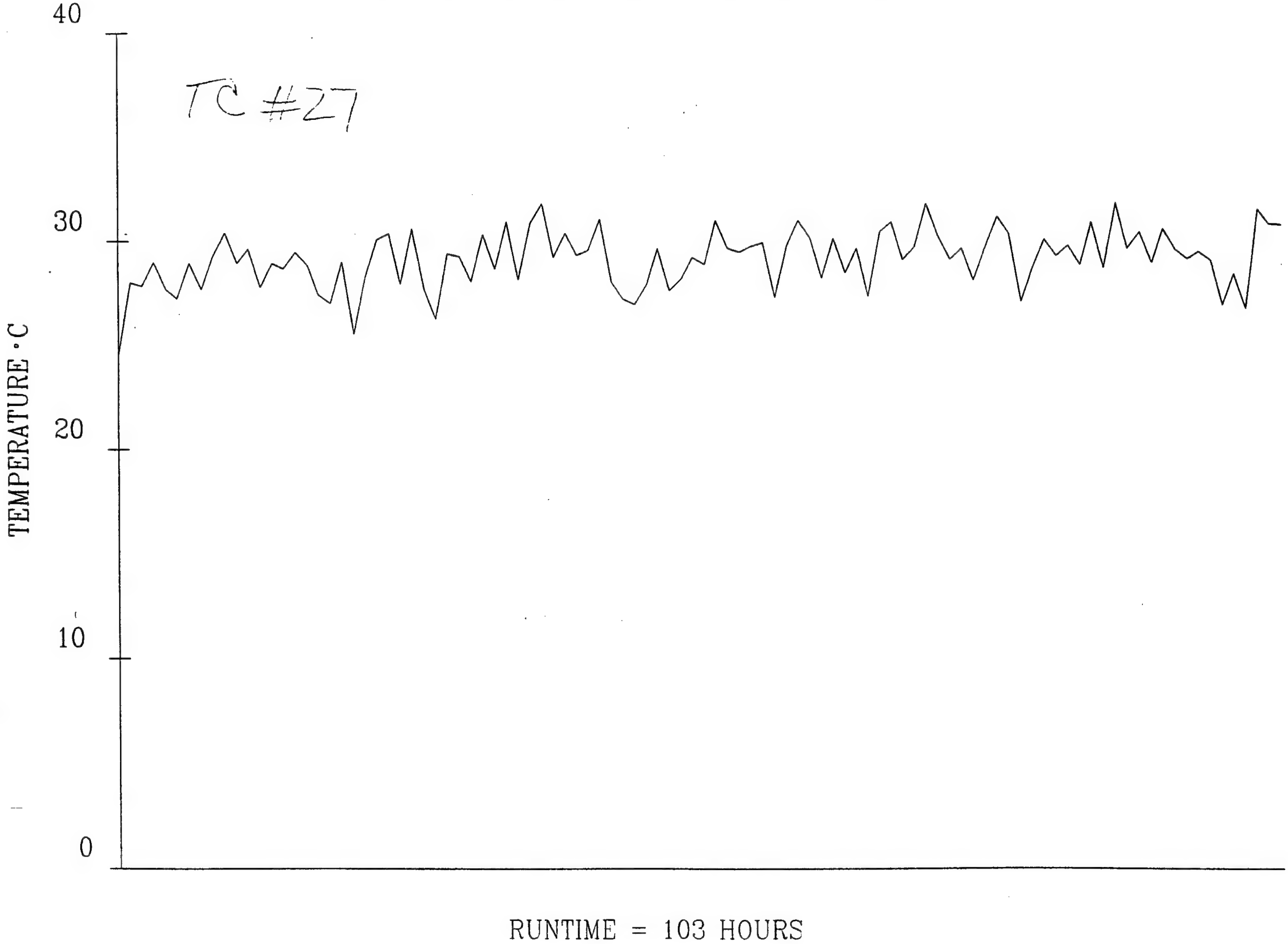

LEFT TOP SEQUENCER BREAK OUT BOARD
40
30
20
10
0
TEMPERATURE ·C
RUNTIME = 103 HOURS

BOTTOM OF RIGHT CABINET

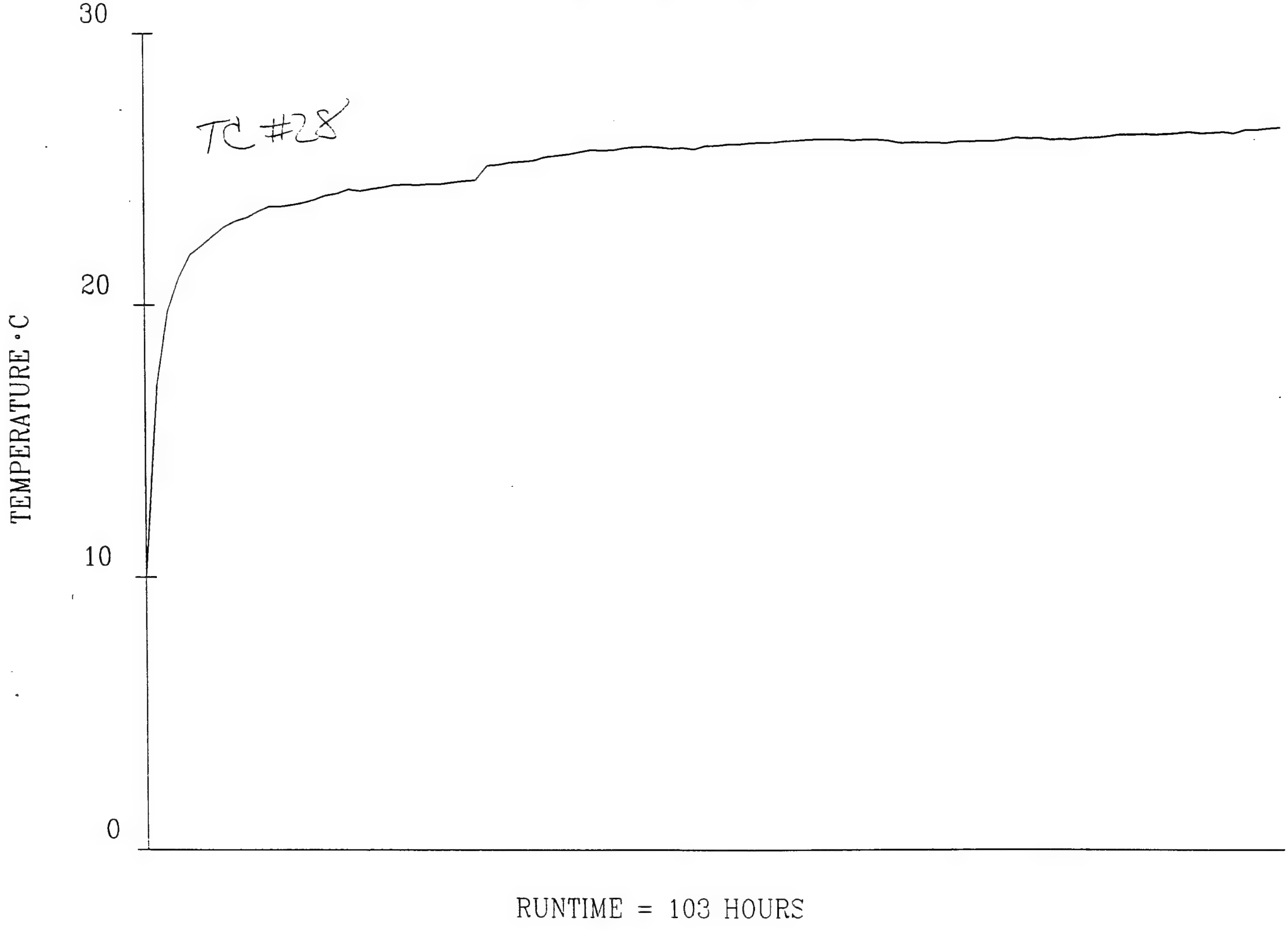


RUNTIME = 103 HOURS

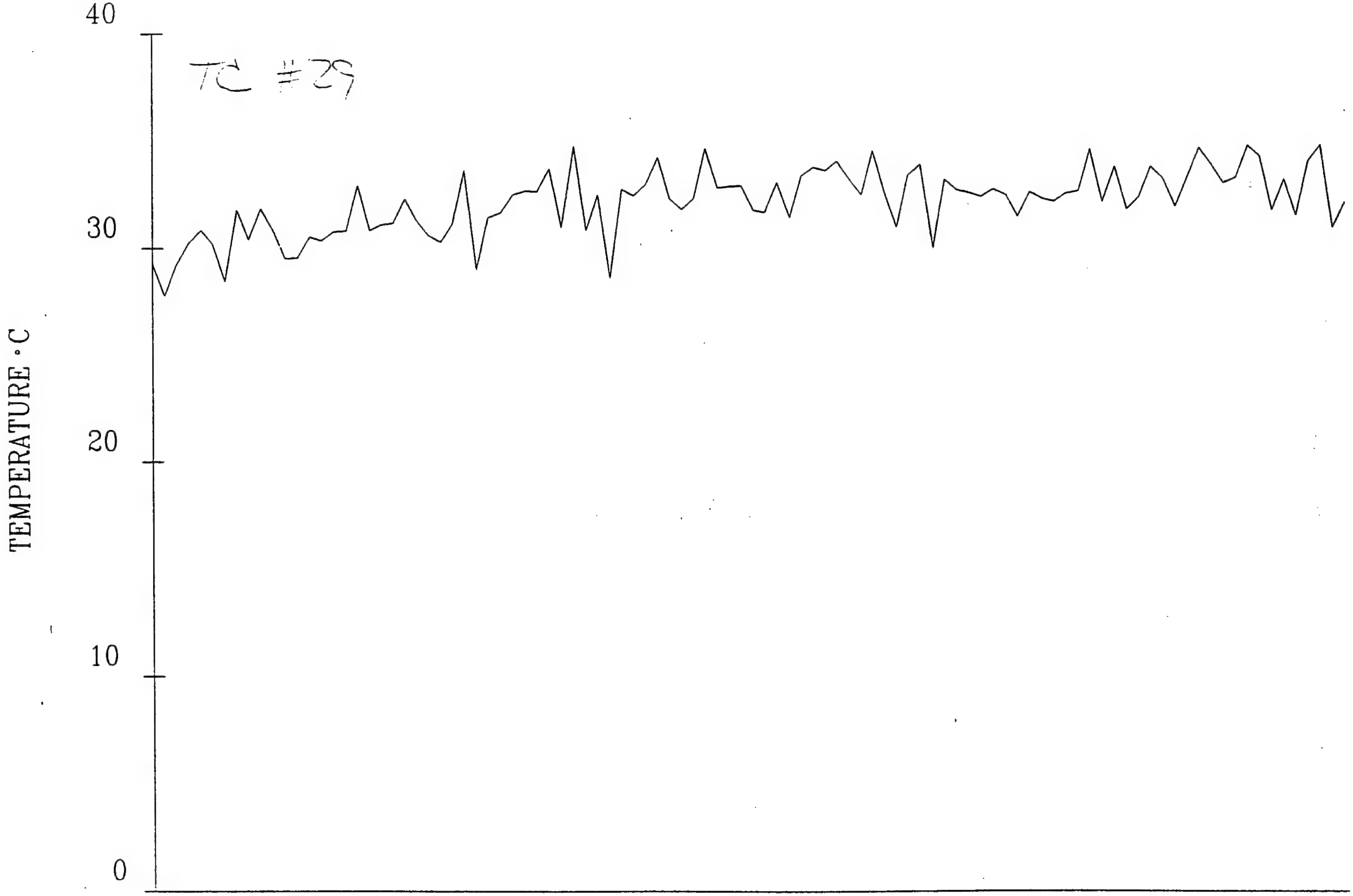
LEFT BOTTOM SEQUENCER BREAKOUT BOARD



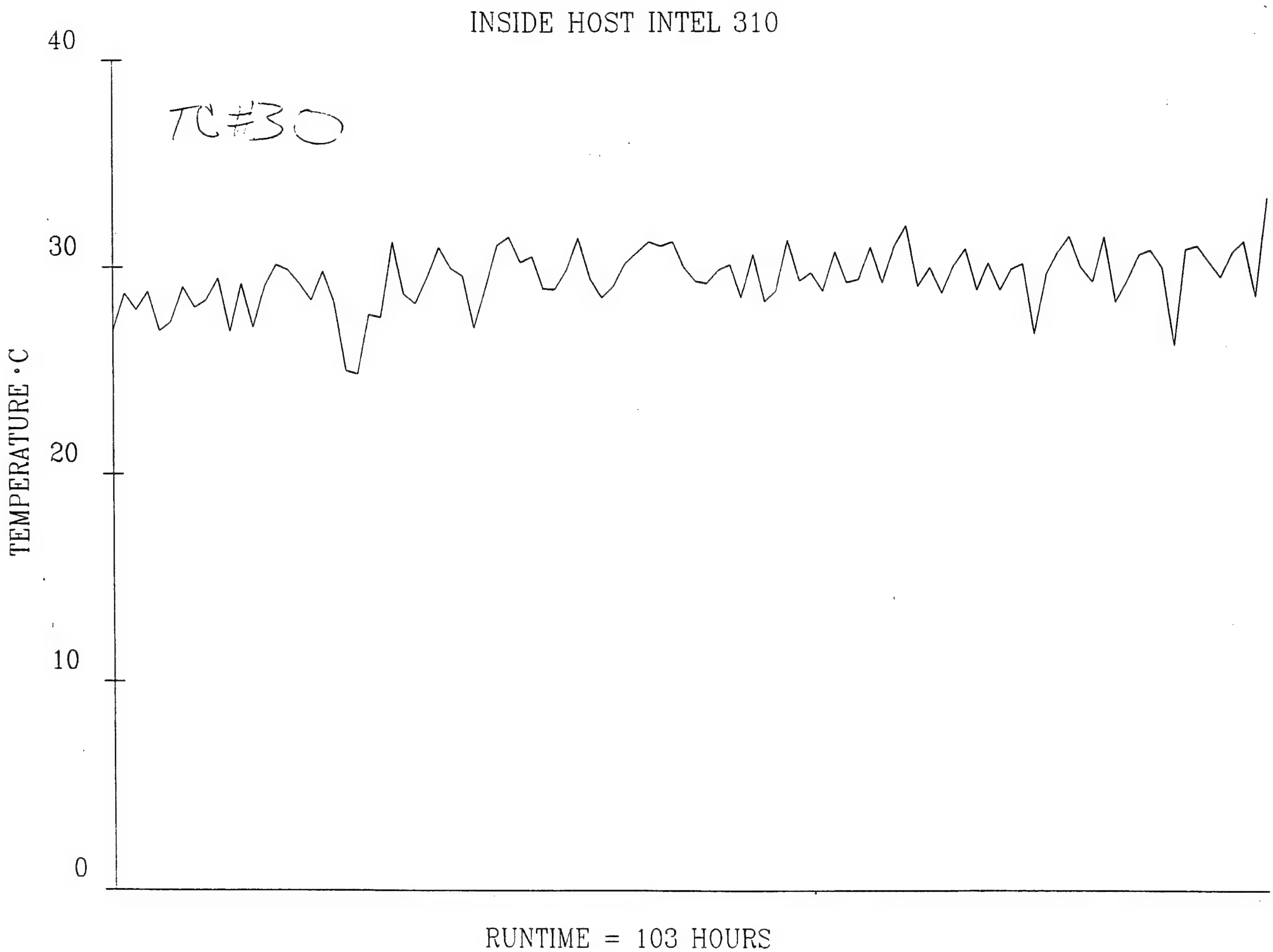
RIGHT TOP SEQUENCER BREAKOUT BOARD

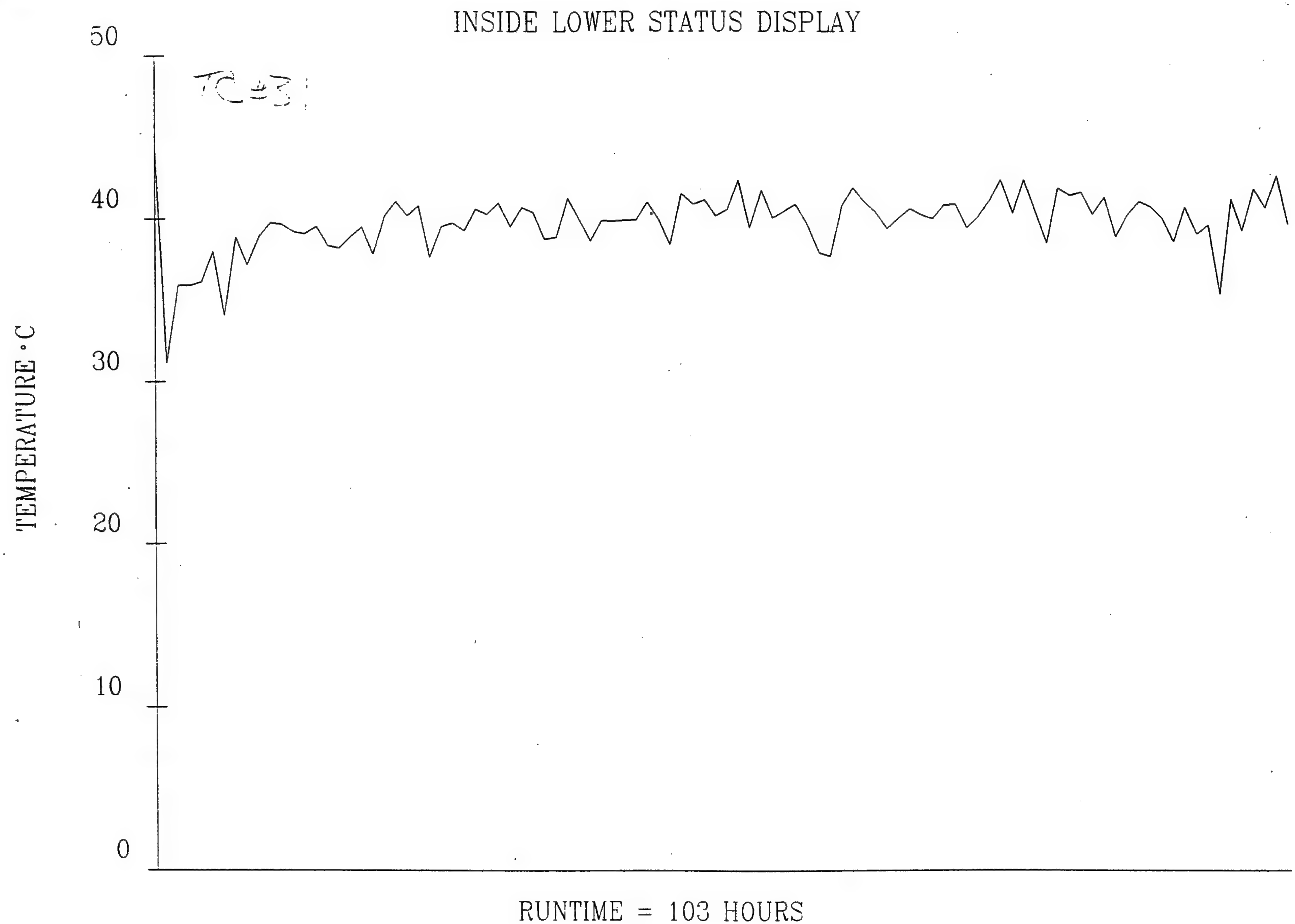


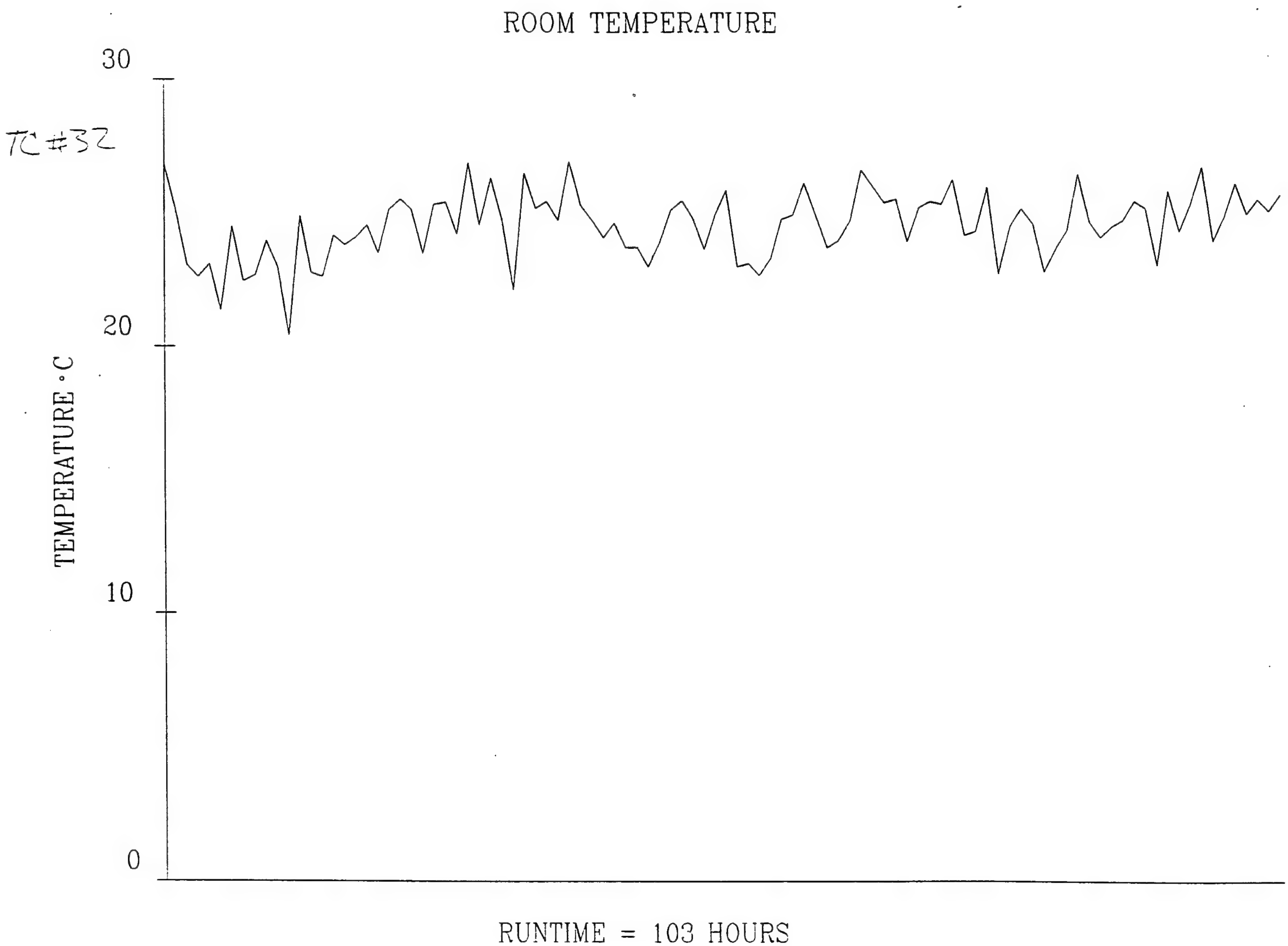
RIGHT BOTTOM SEQUENCER BREAKOUT BOARD



RUNTIME = 103 HOURS


INSIDE HOST INTEL 310
TC#30
40
30
20
10
0
TEMPERATURE •C
RUNTIME = 103 HOURS


INSIDE LOWER STATUS DISPLAY
TC#3
50
40
30
20
10
0
TEMPERATURE • C
RUNTIME = 103 HOURS



ROOM TEMPERATURE
30
TC #32
20
TEMPERATURE •C
10
0
RUNTIME = 103 HOURS

10.2 Appendix B Test Programs

```
Module hostiot;

$include('/spock/def/bitfunc.def')
$include('/spock/def/sysinfo.def')
$include('/spock/def/multiio.def')
$include('/spock/def/slaveio.def')
$include(/spock/fpp/amd/hostio.def)

{ This is the host program for the T2 or handshake diagnostic.
This program takes the processors listed in t2proc and writes
a value to the first one. That processor (processor 1) in turn
(over the crossbar) sequentially writes that value to and
reads that value from the remaining processors in the list to
validate the transfer. (The approach for this test looks much
like the center of a wheel reaching out one at a time to
proccessors that are on the end of the spokes. Where the
center of the wheel is processor 1.) Four different patterns
are transfered (0000,5555,AAAA,FFFF).  }

program hostiot(input,output,outlog,proclist,TESTINFO);
const
    maxPROC = 64;

var
  rs,rr : real;
  NumProc,i,k,loop,error,count:integer;
  l : longint;
  outlog,proclist,TESTINFO :text;
  fpp_page_port ,fpp_page :array [1..maxPROC] of word;
  kount,lsend,lrec : longint;
  T1,T2,I1,I2,cntr : integer;

$include ('/spock/util/screen.src')

{ This included procdure writes a long integer in hex format.
}

$include (/spock/fpp/amd/hex.hst)


begin

{ Read the file TESTINFO for the number of times to run this
test. }

  T2:=0;
  reset(TESTINFO);
  if eof(TESTINFO) then
    writeln('File TESTINFO not found, run TESTSETUP');
  if not eof(TESTINFO) then
  begin
    readln(TESTINFO,T1,I1);
    readln(TESTINFO,T2,I2);
  end;
```

```
    cntr:=0;

{ Loop for the number of times specified in TESTINFO. }

    while cntr < I1 do
    begin
      cntr:=cntr+1;
      for k := 1 to 4 do
      begin
        gotoxy(28,20);
        print_lngint_hex(output,lsend[k]);
        for i := 1 to NumProc do
        begin

{ Write an 'M' under the processor being tested. }

          if i > 48 then
            gotoxy(13+((i-49)*3),17)
          else if i > 32 then
            gotoxy(13+((i-33)*3),14)
          else if i > 16 then
            gotoxy(13+((i-17)*3),11)
          else
            gotoxy(13+((i-1)*3),8);
          write('  M');

{ Set-up a communication channel to the processor being
tested. }

           turn_on_repeater(fpp_page_port[i],fpp_page[i]);

{ Send a value to the processor. }

            longint_send(lsend[k]);

          if i > 48 then
            gotoxy(13+((i-49)*3),17)
          else if i > 32 then
            gotoxy(13+((i-33)*3),14)
          else if i > 16 then
            gotoxy(13+((i-17)*3),11)
          else
            gotoxy(13+((i-1)*3),8);

{ Receive the value back from the processor to validate the
transfer (The processor just echos the value.). }

            lrec := longint_receive;

{ If the values are equal, meaning the transfer was okay, the
'M' under that processor number is blanked out. }

          if ( (lsend[k]-lrec) = 0.0) then
              write('   ')
```

```
            else

{ If the transfer failed, an 'E' is written over the 'M' and
an error message including the processor being tested, the
value sent to the processor, and the value received from the
processor is written to the outlog. }

            begin
              write('  E');
              error := error + 1;
              gotoxy(20,22);
              write('Last error : Processor ',i:2,' sent ');
            print_lngint_hex(output,lsend[k]);
            write('received ');
            print_lngint_hex(output,lrec);

            write(outlog,'Error   Processor ',i:2,' sent ');
            print_lngint_hex(outlog,lsend[k]);
            write(outlog,' and received ');
            print_lngint_hex(outlog,lrec);
            writeln(outlog,' ');

           end;
            count := count + 1;
            if (count > 32000) then
              count := 1;

            gotoxy (10,24);
           write(' Number of transfers = ',count:12,' Number
of Errors = ',error);
            turn_off_repeater(fpp_page_port[i]);
          end;
       end;
     end;

{ The total number of transfers and errors are written to the
outlog after the test is finished. }

    writeln(outlog,'Number of transfers = ',count:12,'
Number of errors = ',error);
    writeln(outlog,' ');
  end;
end.
```

```
Module hostiot;

$include('/spock/def/bitfunc.def')
$include('/spock/def/sysinfo.def')
$include('/spock/def/multiio.def')
$include('/spock/def/slaveio.def')
$include(/spock/fpp/amd/hostio.def)

{ This is the host program for the fppmu diagnostic. This
program takes a list of processors (fppmuproc) and in turn
sequentially writes a value to and reads that value from each
processor over the multibus to validate the transfer. Four
patterns (0000,5555,AAAA,FFFF) are used. }

program hostiot(input,output,outlog,TESTINFO,proclist);
const
    maxPROC = 64;

var
  rs,rr : real;
  NumProc,i,k,error,count,T1,I1,cntr:integer;
  l,lrec : longint;
  fpp_page_port ,fpp_page :array [1..maxPROC] of word;
  proclist,outlog,TESTINFO:text;
  lsend : array[1..10] of longint;


$include ('/spock/util/screen.src')

{ This included procedure prints a long integer in hex format.
}

$include (/spock/fpp/amd/hex.hst)

begin

{ Read the file TESTINFO for the number of times to run this
test. }

  T1:=0;
  reset(TESTINFO);
  if eof(TESTINFO) then
    writeln('File TESTINFO not found, run TESTSETUP.');
  if not eof(TESTINFO) then
    readln(TESTINFO,T1,I1);
  if T1 = 1 then
  begin

    rewrite(outlog);
    writeln(outlog,'*************************************');
    writeln(outlog,'******* Starting FPPMU test. *******');
    writeln(outlog,'******* Iterations = ',I1:6,'  *******');
    writeln(outlog,'*************************************');
    writeln(outlog,' ');
```

```
    reset(proclist);

    i := 0;

{ Read all the processor addresses from the file FPPMUPROC,
and initialize each one. }

    while not eof(proclist) do
    begin
      i := i + 1;
      writeln('reading processor ',i:2);
      readln(proclist,fpp_page_port[i],fpp_page[i]);
      writeln('Processor ',i:2,' at page ',fpp_page[i],' of
page port ',fpp_page_port[i]);
      initialize(fpp_page_port[i],fpp_page[i]);
    end;
    NumProc := i;

{ Set-up the screen. }

    clearscreen;
    gotoxy(0,7);
    write('Processor : ');

{ Write the numbers of each processor to be tested to the
screen. }

    for i := 1 to NumProc do
    begin
      if i > 48 then
        gotoxy(13+((i-49)*3),16)
      else if i > 32 then
        gotoxy(13+((i-33)*3),13)
      else if i > 16 then
        gotoxy(13+((i-17)*3),10);
       write(i:3);
    end;

    gotoxy(5,20);
    write('Pattern transferring : ');

{ Values to be sent. When the constant to be sent had the most
significant bit set it caused problems, but if you summed
numbers that didn't have the MSB set, the result could be sent
without problems. }

    lsend[1] := 02aaaaaaah + 40000000h + 40000000h;
    lsend[2] := 07fffffffh + 40000000h + 40000000h;
    lsend[3] := 055555555h;
    lsend[4] := 000000000;

    error := 0;
    count := 0;
```

```
  if T2 = 1 then
  begin

    rewrite(outlog);
    writeln(outlog,'*************************************');
    writeln(outlog,'******* Handshake (T2) test. *******');
    writeln(outlog,'******* Iterations = ',I2:6,'  *******');
    writeln(outlog,'*************************************');
    writeln(outlog,' ');
    i := 0;
    error := 0;

{ read all the processor addresses from t2proc. }

    reset(proclist);
    while not eof(proclist) do
    begin
      i := i + 1;
      writeln('reading processor ',i:2);
      readln(proclist,fpp_page_port[i],fpp_page[i]);
      writeln('Processor ',i:2,' at page ',fpp_page[i],' of
page port ',fpp_page_port[i]);
    end;

    NumProc := i;

{ Set-up the screen. }

    clearscreen;
    gotoxy(5,8);
    write('value sent ');
    gotoxy(22,2);
    write('# cycled patterns ');

    kount := 0;

{ Initialize processor 1. This will be the processor which
broadcasts to each of the other processors, one at a time,
over the crossbar, then reads the value back from each
processor to validate the transfer. The approach for this test
looks much like the center of a wheel reaching out one at a
time to proccessors that are on the end of the spokes. Where
the center of the wheel is processor 1. }

    initialize(fpp_page_port[1],fpp_page[1]);

    cntr:=0;

{ Loop for the number of times specified in TESTINFO. }

    while cntr < I2 do
    begin
      cntr:=cntr+1;
      for l := 2 to Numproc do
```

```
        for k := 1 to 4 do
        begin
          kount := kount +1;
          gotoxy(40,2);
          write(kount);

{ Initialize the processor to be sent to, and set-up a
communication channel. }

          initialize(fpp_page_port[l],fpp_page[l]);
          turn_on_repeater(fpp_page_port[1],fpp_page[1]);
          case k of

{ Values to be sent. (When the constant to be sent had the
most significant bit set it caused problems, but if you summed
numbers that didn't have the MSB set, the result could be sent
without problems. }

{                    1: lsend := 02aaaaaaah + 40000000h +
40000000H;   }
                   1,3: lsend := 07fffffffh + 40000000h +
40000000h;
{                    3: lsend := 055555555h;   }
                   2,4: lsend := 0h {+ 40000000h + 40000000h};
        end;
      gotoxy(17,8);
      write('bfor snd');

{ Send data over the crossbar from processor 1 to processor L.
}

      longint_send(lsend);
      gotoxy(17,8);
      print_lngint_hex(output,lsend);
      write(' to check P',(l-1):2);
      gotoxy(43,11);
      write('     ');

{ Close the communication channel between processor 1 and the
host. }

      turn_off_repeater(fpp_page_port[1]);

      begin

{ Open a communication channel to the processor that data was
just sent to. }

        turn_on_repeater(fpp_page_port[l],fpp_page[l]);

{ Receive data from processor L (Processor L just echos the
data.). }

        lrec := longint_receive;
```

```
        gotoxy(17,10);
        print_lngint_hex(output,lrec);
        write(' received from P',(l-1):2);
        gotoxy(17,11);
        print_lngint_hex(output,lrec);
        write(' sending to    P');
        write(0:2);
        lrec := longint_receive;
        write(' sent');

{ If the processor under test didn't echo the data correctly,
an error message including the processor number under test and
the difference between what was sent and what was received
back. }

        if (lsend <> lrec) then
        begin
          gotoxy(26,20);
          write('error ');
          write(outlog,'error ');
          error := error + 1;
          print_lngint_hex(output,(lsend-lrec));
          write(' while checking P',(l-1):2,' # ',error);
          print_lngint_hex(outlog,(lsend-lrec));
          writeln(outlog,' while checking P',(l-1):2,' #
',error);
        end;

{ Close the communication channel from processor L. }

        stop_processor;
        turn_off_repeater(fpp_page_port[l]);
      end;

{ Open the communication channel from processor 1. }

      turn_on_repeater(fpp_page_port[1],fpp_page[1]);
      lrec := longint_receive

{ If the processor under test didn't echo the data correctly,
an error message including the processor number under test and
the difference between what was sent and what was received
back. }

      if (lsend <> lrec) then
      begin
        gotoxy(26,20);
        write('error ');
        write(outlog,'error ');
        error := error + 1;
        print_lngint_hex(output,(lsend-lrec));
        write(' while checking P',(l-1):2,' # ',error);
        print_lngint_hex(outlog,(lsend-lrec));
```

```
        writeln(outlog,' while checking P',(l-1):2,' #
',error);
      end;
    end;
  end;

{ The number of cycled patterns and the running total of
errors are written to the outlog after the test finishes. }

writeln(outlog,'Number of cycled patterns = ',kount,'  Number
of errors = ',error);
  writeln(outlog,' ');
end.
```

```
Module t3;

$include('/spock/def/bitfunc.def')
$include('/spock/def/sysinfo.def')
$include('/spock/def/multiio.def')
$include('/spock/def/slaveio.def')
$include(/spock/fpp/amd/hostio.def)

{ This is the host program for the first run of the T3
diagnostic. This program takes a list of processors (t3proc) and
cycles through the list beginning with the first making each a
sending processor and the rest of the list receiving processors.
This is then done for the second and so on to the end of the
list and then the sequence is repeated. During this test cycle
each receiving processor is checked to verify the validity of
the transfer [errors are written to the screen and to outlog
(:lp:?)]. The number of transfers, the number of errors, list of
processors, and the value being sent are displayed. An 'S'
adjacent to the sending processor number indicates such. The
purpose of this program is to stress various parts of the system
(e.g., processors, crossbar boards, cables, etc.) The scheme of
this program is to read in an ordered list of processors and
sets the sender and receivers and then send the value to the
sending processor (which sends it across network) and then
checks the receiving processors for the data received.  }

program t3(input,output,outlog,proclist,TESTINFO);
const
    maxPROC = 64;

var
  rs : array [1..10] of real;
  rr,count : real;
  NumProc,i,k,loop,error,T1,T2,T_3,I1,I2,I3,cntr : integer;
  l : longint;
  lsend : array[1..10] of longint;
  lrec : array [1..maxProc] of longint;
  outlog,proclist,TESTINFO : text;
  fpp_page_port ,fpp_page : array [1..maxPROC] of word;
  ProcErr : boolean;

$include ('/spock/util/screen.src')
$include (/spock/fpp/amd/hex.hst)

begin

{ Read the file TESTINFO for the number of times to run this
test. }

  T_3:=0;
  reset(TESTINFO);
  if eof(TESTINFO) then
    writeln('File TESTINFO not found, run TESTSETUP.');
  if not eof(TESTINFO) then
```

```
  begin
    readln(TESTINFO,T1,I1);
    readln(TESTINFO,T2,I2);
    readln(TESTINFO,T_3,I3);
  end;
  if T_3 = 1 then
  begin

    reset(proclist);
    rewrite(outlog);
    writeln(outlog,'*************************************');
    writeln(outlog,'***** Starting Xbar (T3) test. *****');
    writeln(outlog,'***** Iterations = ',I3:6,'      *****');
    writeln(outlog,'*************************************');
    writeln(outlog,' ');

{ Read the addresses of all the processors from T3PROC and
initialize each of them. }

    i := 0;

    while not eof(proclist) do
    begin
      i := i + 1;
      writeln('reading processor ',i:2);
      readln(proclist,fpp_page_port[i],fpp_page[i]);
      writeln('Processor ',i:2,' at page ',fpp_page[i],' of page
port ',fpp_page_port[i]);
      initialize(fpp_page_port[i],fpp_page[i]);
    end;
    NumProc := i;

{ Set-up the screen. }

    clearscreen;
    gotoxy(0,7);
    write('Xbar test : ');
    for i := 1 to NumProc do
      begin
        if i > 48 then
            gotoxy(13+((i-49)*3),16)
        else if i > 32 then
            gotoxy(13+((i-33)*3),13)
        else if i > 16 then
            gotoxy(13+((i-17)*3),10);
         write((i-1):3);
      end;

    gotoxy(5,20);
    write('Pattern transferring : ');

{ Values to be transfered. When the constant to be sent had the
most significant bit set it caused problems, but if you summed
```

```
numbers that didn't have the MSB set, the result could be sent
without problems. }

    lsend[1] := 02aaaaaaah + 40000000h + 40000000H;
    lsend[2] := 07fffffffh + 40000000h + 40000000h;
    lsend[3] := 055555555h;
    lsend[4] := 000000000h;

    error := 0;
    count := 0.0;
    cntr:=0;

{ Loop the number of times specified in the file TESTINFO. }

    while cntr < I3 do
    begin
      cntr:=cntr+1;
      for k := 1 to 4 do
        for loop := 1 to NumProc do       { cycle through list,
loop = sender}
        begin

          ProcErr := False;

          for i := 1 to NumProc do   {set one to send and others
to receive}
            if i = loop then
            begin
              turn_on_repeater(fpp_page_port[i],fpp_page[i]);
              real_send(1.0);
              turn_off_repeater(fpp_page_port[i]);
            end
            else
            begin
              turn_on_repeater(fpp_page_port[i],fpp_page[i]);
              real_send(0.0);
              turn_off_repeater(fpp_page_port[i]);
            end;

{ send value ,lsend[k], to sending processor }

          turn_on_repeater(fpp_page_port[loop],fpp_page[loop]);
          gotoxy(30,20);
          print_lngint_hex(output,lsend[k]);
          longint_send(lsend[k]);
          turn_off_repeater(fpp_page_port[loop]);

{ read values received by the processors and compare to value
sent }

          for i := 1 to NumProc do
            if i <> loop then
            begin
```

```
{ read value from processor }

              turn_on_repeater(fpp_page_port[i],fpp_page[i]);
              lrec[i] := longint_receive;
              turn_off_repeater(fpp_page_port[i]);

{ compare values and set error flag }

              if (lsend[k] <> lrec[i]) then
                ProcErr := True;
            end;

{ position cursor }

              if loop > 48 then
                gotoxy(13+((loop-49)*3),17)
            else if loop > 32 then
                gotoxy(13+((loop-33)*3),14)
            else if loop > 16 then
                gotoxy(13+((loop-17)*3),11)
            else
                gotoxy(13+((loop-1)*3),8);

            if not ProcErr then
            begin
              write('  S');
              if loop > 48 then
                 gotoxy(13+((loop-49)*3),17)
              else if loop > 32 then
                 gotoxy(13+((loop-33)*3),14)
              else if loop > 16 then
                 gotoxy(13+((loop-17)*3),11)
              else
                 gotoxy(13+((loop-1)*3),8);
              write('   ');
            end
            else
            begin
              write('  E');
              for i := 1 to NumProc do
                if i <> loop then
                  if (lsend[k] <> lrec[i]) then
                  begin
                    error := error + 1;
                    gotoxy(0,22);

{ write out sending and receiving processors, sent and received
values and error }

                    write('Last error : P',(loop-1):2,' sent ');
                    print_lngint_hex(output,lsend[k]);
                    write(' P',(i-1):2,' received ');
                    print_lngint_hex(output,lrec[i]);
                    write(' error ');
```

```
                    print_lngint_hex(output,lsend[k]-lrec[i]);
                    writeln;

{write to error to outlog (:LP:?) }

                    write(outlog,'error : P',(loop-1):2,' sent
');

                    print_lngint_hex(outlog,lsend[k]);
                    write(outlog,' P',(i-1):2,' received ');
                    print_lngint_hex(outlog,lrec[i]);
                    write(outlog,' error ');
                    print_lngint_hex(outlog,lsend[k]-lrec[i]);
                    writeln(outlog);
                  end;
            end;
            count := count + (NumProc-1);

            gotoxy (10,24);
            write(' Number of transfers = ',count:12:1,' Number
of Errors : ',error);
        end;
    end;
    writeln(outlog,'Number of transfers = ',count:12:1,' Number
of errors = ',error);
    writeln(outlog,' ');
  end;
end.
```

```
Module hostiot;

$include('/spock/def/bitfunc.def')
$include('/spock/def/sysinfo.def')
$include('/spock/def/multiio.def')
$include('/spock/def/slaveio.def')
$include(/spock/fpp/amd/hostio.def)

{ This is the host program for the ftest diagnostic. This
program tests the function calculation of the processors
listed in funcproc. For each of the 10 functions
(sine,cosine,tangent,arcsine,arccosine,arctangent,reciprocal,
exponential,square root, and natural log) numbers over some
respective range are sent to the processor and the processor
returns the values of the function. These results are each
compared to the values computed by the host to validate the
calculation. All 10 functions are tested on one processor
before testing the next processor in the list. }

program hostiot(input,output,proclist,TESTINFO,outlog);
const
    maxPROC = 64;

var

numproc,i,k,error,tot_err,count,bad,cntr,T1,T2,T3,T4,I1,I2,I3,
I4 :integer;
  fpp_page_port ,fpp_page :array [1..maxPROC] of word;
  proclist, outlog, TESTINFO : text;
  lsend : array[1..10] of longint;
  done : boolean;
  choice : char;

$include ('/spock/util/screen.src')

{ This procedure computes the value of sin(x) for -1<=x<=+1 in
0.01 increments. If the result is off by more than 0.00000026
it is flagged as bad by setting the variable bad==1. When an
error occurs, the value of x, sin(x) computed by the FPP,
sin(x) computed by the HOST, and the difference is written to
the outlog. }

procedure test_sine;
var
  line_count,page,errors : integer;
  x,y,z,diff,tolerance : longreal;

begin
  line_count := 1;
  page := 1;
  tolerance := 0.00000026;
  errors := 0;
  x := -1.0;
  while (x <= 1.0) do
```

```
  begin
    send(1);
    real_send(x);
    y := real_receive;
    diff := (abs(y-sin(x)));
    if diff > tolerance then
    begin
       if line_count = 1 then
      begin
        write(outlog,' X        Remote Sine       Local
Sine');
        writeln(outlog,'      Difference',
                      ' on ',fpp_page_port[i],'
',fpp_page[i]);
        writeln(outlog,' -------------------------------------
-----------------------------');
        line_count := 2;
      end;
      errors := errors + 1;
      write(outlog,x:4:2,'      ',y:10:6);
      writeln(outlog,'       ',sin(x):10:6,'
',diff:8:8);
    end;
    x := x + 0.01;
    z := z + 1;
  end;
  if errors <> 0 then
  begin
    bad := 1;
    writeln(outlog);
    writeln(outlog,errors,' errors have occurred in Sine
function');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
  end;
end;


{ This procedure computes the value of cos(x) for 0<=x<=PI in
1 degree increments. If the result is off by more than
0.00000025 it is flagged as bad by setting the variable
bad==1. When an error occurs, the value of x (radians), the
value of x (degrees), cos(x) computed by the HOST, cos(x)
computed by the FPP, and the difference is written to the
outlog. }

procedure test_cosine;
const
  PI = 3.1415927;
var
  line_count,page,errors : integer;
  rad,degr,y,tolerance,diff : longreal;
```

```
  begin
    errors := 0;
     tolerance := 0.00000025;
    line_count := 1;
    page := 1;
    degr := 0.0;
    rad := 0.0;{  Just to get inside the loop}
    while (rad <= PI) do
    begin
       rad := (degr*PI)/180;
      send(2);
       real_send(rad);
      y := real_receive;
      diff := (abs(y-cos(rad)));
      if diff > tolerance then
      begin
        errors := errors + 1;
          if line_count = 1 then
     begin
            write(outlog,'X(Radians)    X(Degrees)    Local ');
            writeln(outlog,'Cos      Remote Cos
Difference',
                                          ' on ',fpp_page_port[i],'
',fpp_page[i]);
             writeln(outlog,'------------------------------------
--------------------------------');
             line_count := 2;
     end;
         write(outlog,rad:8:6,'     ',degr:5:1,'
',cos(rad):11:6);
         writeln(outlog,'    ',y:11:6,'       ',diff:8:8);
       end;
      degr := degr + 1.0;
    end;
     if errors <> 0 then
    begin
      bad := 1;
      writeln(outlog);
      writeln(outlog,errors,' errors occured in Cosine
function.');
      writeln(outlog,'Processor',i:2);
      writeln(outlog);
      tot_err:=tot_err+errors;
    end;
  end;

{ This procedure computes the value of tan(x) for 0<=x<=PI
x<>PI/2 in 1 degree increments. If the result is off by more
than 0.00014287 it is flagged as bad by setting the variable
bad==1. When an error occurs, the value of x(radians), the
value of x(degrees), tan(x) computed by the HOST, tan(x)
computed by the FPP, and the difference is written to the
outlog. }
```

```
procedure test_tangent;
const
  PI = 3.1415927;
var
  line_count,page,errors : integer;
  rad,degr,y,tolerance,diff : longreal;
  begin
     errors := 0;
    tolerance := 0.00014287;
    line_count := 1;
    page := 1;
    degr := 0.0;
    rad := 0.0;
    while (rad <= PI) do
    begin
       rad := (degr*PI)/180;
      if degr <> 90 then
       begin
          send(3);
          real_send(rad);
          y := real_receive;
          diff := (abs(y-tan(rad)));
        if diff > tolerance then
        begin
          errors := errors + 1;
           if line_count = 1 then
       begin
               write(outlog,'X(Radians)    X(Degrees)    ');
               writeln(outlog,' Tangent      FFS Tangent
Difference',
                                ' on ',fpp_page_port[i],'
',fpp_page[i]);
               writeln(outlog,'------------------------------
-------------------------------------');
          line_count := 2;
          end;
           write(outlog,rad:8:6,'        ',degr:5:1,'
',tan(rad):11:6);
           writeln(outlog,'    ',y:11:6,'       ',diff:8:8);
         end;
       end;

      degr := degr + 1.0;
    end;
    if errors <> 0 then
    begin
      bad :=1;
      writeln(outlog);
      writeln(outlog,errors,' errors in tangent function.');
      writeln(outlog,'Processor ',i:2);
      writeln(outlog);
      tot_err:=tot_err+errors;
    end;
   end;
```

```
{ This function is the coding of the algorithm used on the FPP
for arcsin }

function asin(x : longreal) : longreal;
const
  PI  =  3.14159265;
  P1  =  1.5707963050;
  P2  = -0.2145988016;
  P3  =  0.0889789874;
  P4  = -0.0501743046;
  P5  =  0.0308918810;
  P6  = -0.0170881256;
  P7  =  0.0066700901;
  P8  = -0.0012624911;
var t,temp,temp2 : longreal;
begin
  t := abs(x);
  temp2 := P8 * t;
  temp2 := temp2 + P7;
  temp2 := temp2 * t;
  temp2 := temp2 + P6;
  temp2 := temp2 * t;
  temp2 := temp2 + P5;
  temp2 := temp2 * t;
  temp2 := temp2 + P4;
  temp2 := temp2 * t;
  temp2 := temp2 + P3;
  temp2 := temp2 * t;
  temp2 := temp2 + P2;
  temp2 := temp2 * t;
  temp2 := temp2 + P1;
  temp2 := temp2 * sqrt(1-t);
  temp := (PI/2) - temp2;
  if x < 0 then
     temp := -temp;
  asin := temp;
end;

{ This procedure computes the value of arcsin(x) for -1<=x<=+1
in 0.01 increments. If the result is off by more than
0.00000031 it is flagged as bad by setting the variable
bad==1. When an error occurs, the value of x, arcsin(x)
computed by the HOST, arcsin(x) computed by the FPP, and the
difference is written to the outlog. }

procedure test_arcsine;
var
  line_count,page,errors : integer;
  x,y,tolerance,diff : longreal;

begin
  errors := 0;
  tolerance := 0.00000031;
```

```
  line_count := 1;
  page := 1;

  x := -1.0;
  while (x <= 1.0) do
  begin
    send(4);
     real_send(x);
    y := real_receive;
     diff := (abs(y-asin(x)));
    if diff > tolerance then
    begin
      errors := errors + 1;
       if line_count = 1 then
      begin
        write(outlog,'  X          ArcSine        FFS
ArcSine');
         writeln(outlog,'       Difference',
                                    ' on ',fpp_page_port[i],'
',fpp_page[i]);
         writeln(outlog,'-------------------------------------
----------------------');
         line_count := 2;
      end;
       write(outlog,x:4:2,'      ',asin(x):10:6);
       writeln(outlog,'       ',y:10:6,'        ',diff:8:8);
     end;
    x := x + 0.01;
  end;
  if errors <> 0 then
  begin
    bad := 1;
    writeln(outlog);
     writeln(outlog,errors,' errors in ArcSine function.');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
  end;
end;


{ This procedure computes the value of arccos(x) for -1<=x<=+1
in 0.01 increments. If the result is off by more than
0.00000036 it is flagged as bad by setting the variable
bad==1. When an error occurs, the value of x, arccos(x)
computed by the HOST, arccos(x) computed by the FPP, and the
difference is written to the outlog. }

procedure test_arccosine;
var
  line_count,page,errors : integer;
  x,y,tolerance,diff : longreal;

function acos(x : real) : real;
```

```
const
  PI = 3.14159265;
begin
  acos := PI/2 - asin(x);
end;


begin
  errors := 0;
  tolerance := 0.00000036;
  line_count := 1;
  page := 1;
  x := -1.0;
  while (x <= 1.0) do
  begin
    send(5);
     real_send(x);
    y := real_receive;
     diff := (abs(y-acos(x)));
    if diff > tolerance then
    begin
      errors := errors + 1;
       if line_count = 1 then
       begin
        write(outlog,'  X         ArcCosine      FFS
ArcCosine');
          writeln(outlog,'      Difference',
                                 ' on ',fpp_page_port[i],'
',fpp_page[i]);
          writeln(outlog,'-------------------------------------
-------------------------------');
          line_count := 2;
       end;
       write(outlog,x:4:2,'     ',acos(x):10:6);
      writeln(outlog,'       ',y:10:6,'        ',diff:8:8);
     end;
    x := x + 0.01;
  end;
  if errors <> 0 then
  begin
    bad := 1;
    writeln(outlog);
    writeln(outlog,errors,' errors in ArcCosine function.');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
  end;
end;


{ This procedure computes the value of arctan(x) for -1<=x<=+1
in 0.01 increments. If the result is off by more than
0.00000008 it is flagged as bad by setting the variable
bad==1. When an error occurs, the value of x, arctan(x)
```

```
computed by the HOST, arctan(x) computed by the FPP, and the
difference is written to the outlog. }

procedure test_arctangent;
var
  line_count,page,errors : integer;
  x,y,tolerance,diff : longreal;
begin
  errors := 0;
  tolerance := 0.00000008;
  line_count := 1;
  page := 1;
  x := -1.0000000000000;

  while (x <= 1.0000) do
  begin
    send(6);
     real_send(x);
     y := real_receive;
     diff := (abs(y-arctan(x)));
    if diff > tolerance then
    begin
      errors := errors + 1;
      if line_count = 1 then
      begin
          write(outlog,'X            Local ');
          writeln(outlog,'ArcTan    Remote ArcTan  Difference',
                                        ' on ',fpp_page_port[i],'
',fpp_page[i]);
          writeln(outlog,'--------------------------------------
------------------------------');
          line_count := 2;
       end;
       write(outlog,x:8:6,'     ',arctan(x):11:6);
       writeln(outlog,'    ',y:11:6,'       ',diff:8:8);
     end;
     x := x + 0.0100000000000000;
  end;
  if errors <> 0 then
  begin
    bad := 1;
    writeln(outlog);
    writeln(outlog,errors,' errors have occured in
ArcTangent.');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
  end;
end;

{ This procedure computes the reciprocal(x) for x=.00001,
0<=x<=1 by increments of .1, 10<=x<=100 by increments of 1,
100<=x<=1000 by increments of 10, 1000<=x<=10000 by increments
of 100, 10000<=x<=100000 by increments of 1000, and
```

```
100000<=x<=1000000 by increments of 10000. If the result of
reciprocal(.00001) is off more than 0.0078126 or any other
result is off by more than 0.00000045, the result is flagged
as bad. When an error occurs, the value of x, the
reciprocal(x) computed by the HOST, the reciprocal(x) computed
by the FFP, and the difference is written to the outlog. }

procedure test_reciprical;
var
  first_pass : boolean;
  line_count,page,loops,errors : integer;
  x,y,diff,multiplier,tolerance : longreal;
begin
  errors := 0;
  tolerance := 0.0078126;
  line_count := 1;
  loops := 0;{required so that the special case of 0.00001 is
not counted}
  first_pass := true;
  page := 1;
  x := 0.00001;
  while (x <= 1000000) do
  begin
    if (not first_pass) then
      tolerance := 0.00000045;
    send(7);
     real_send(x);
     y := real_receive;
     diff := (abs(y-(1/x)));
    if diff > tolerance then
    begin
      errors := errors + 1;
      if line_count = 1 then
      begin
          write(outlog,'  X          Reciprical         ');
          writeln(outlog,'FFS Reciprical          Difference',
                                      ' on ',fpp_page_port[i],'
',fpp_page[i]);
          writeln(outlog,'--------------------------------------
-------------------------------');
          line_count := 2;
      end;
       if first_pass then
      begin
         write(outlog,x:9:6,'     ',1/x:9:6);
         writeln(outlog,'      ',y:9:6,'       ',diff:9:6);
       end
       else
       begin
         write(outlog,x:9:6,'      ',1/x:9:6);
         writeln(outlog,'      ',y:9:6,'       ',diff:9:6);
       end;
    end;
    if first_pass then
```

```
      begin
        x := 0.00001;
        multiplier := 0.1;
        first_pass := false;
      end;
       if loops = 10 then
      begin
        multiplier := multiplier * 10.0;
         loops := 1;
      end;
       x := x + multiplier;
      loops := loops + 1;
    end;
    if errors <> 0 then
    begin
      bad := 1;
      writeln(outlog);
       writeln(outlog,errors,' errors in Reciprical function.');
      writeln(outlog,'Processor ',i:2);
      writeln(outlog);
      tot_err:=tot_err+errors;
    end;
  end;

  { This procedure computes the exp(x) for x=-1.0e-10, x=1.0e-
  10, and 1<=x<=10 by increments of .1. If the result of exp(x)
  is off more than 0.009110106 the result is flagged as bad.
  When an error occurs, the value of x, the exp(x) computed by
  the HOST, the exp(x) computed by the FFP, and the difference
  is written to the outlog. }

  procedure test_exponential;
  var
    first_pass, second_pass : boolean;
    line_count,page_number,errors : integer;
    x,y,diff,multiplier,tolerance : longreal;
  begin
    errors := 0;
    tolerance := 0.009110106;
    line_count := 1;
    page_number := 1;
    first_pass := true;
    second_pass := true;
    x := -1.0e-8;
    while x <= 10 do
    begin
      send(8);
       real_send(x);
      y := real_receive;
      diff := (abs(y-(exp(x))));
       if diff > tolerance then
      begin
        errors := errors + 1;
         if line_count = 1 then
```

```
      begin
        write(outlog,'  X        Exponential    ');
          writeln(outlog,'      FFS Exponential
Difference',
                                             ' on ',fpp_page_port[i],'
',fpp_page[i]);
        writeln(outlog,'------------------------------------------
-----');
          line_count := 2;
      end;
      if first_pass or second_pass then
          write(outlog,x:8:8,'   ',exp(x):11:6)
       else
         write(outlog,x:9:1,'   ',exp(x):12:6);

         writeln(outlog,'        ',y:12:6,'       ',diff:9:9);
      end;
       if first_pass then
      begin
         x := 1e-8;
          first_pass := false;
      end
       else
      if second_pass then
       begin
        x := 1;
         multiplier := 0.1;
         second_pass := false;
       end
      else
         x := x + multiplier;
       end;
      if errors <> 0 then
      begin
        bad := 1;
        writeln(outlog);
         writeln(outlog,errors,' errors in Exponential
Function.');
        writeln(outlog,'Processor ',i:2);
        writeln(outlog);
        tot_err:=tot_err+errors;
      end;
    end;

{ This procedure computes the square_root(x) for 1<=x<=100 in
increments of 1. If the result of square_root(x) is off more
than 0.00000122 the result is flagged as bad. When an error
occurs, the value of x, the square_root(x) computed by the
HOST, the square_root(x) computed by the FFP, and the
difference is written to the outlog. }

procedure test_square_root;
var
line_count,page,errors : integer;
```

```
x,y,tolerance,diff : longreal;
begin
   errors := 0;
   tolerance := 0.00000122;
   line_count := 1;
   page := 1;
   x := 0.0;
  while (x <= 100) do
   begin
         send(9);
           real_send(x);
           y := real_receive;
           diff := (abs(y-sqrt(x)));
      if diff > tolerance then
       begin
          errors := errors + 1;
          if line_count = 1 then
        begin
                write(outlog,'X       Local ');
                writeln(outlog,'Sqrt       Remote Sqrt
Difference',
                                    ' on ',fpp_page_port[i],'
',fpp_page[i]);
                writeln(outlog,'------------------------------
-----------------------------------');
                line_count := 2;
        end;
             write(outlog,x:5:1,'    ',sqrt(x):11:6);
             writeln(outlog,'    ',y:11:6,'        ',diff:8:8);
       end;
      x := x + 1.0;
    end;
    if errors <> 0 then
    begin
    bad := 1;
    writeln(outlog);
    writeln(outlog,errors,' errors have occured in Square
Root.');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
    end;
end;

{ This procedure computes the Ln(x) for x=.00001, 0<=x<=1 in
increments of .1, 1<=x<=10 in increments of 1, 10<=x<=100 in
increments of 10. If the result of Ln(x) is off more than
0.00000122 the result is flagged as bad. When an error occurs,
the value of x, the Ln(x) computed by the HOST, the Ln(x)
computed by the FFP, and the difference is written to the
outlog. }

procedure test_natural_log;
var
```

```
first_pass : boolean;
line_count,page,loops,errors : integer;
x,y,diff,multiplier,tolerance : longreal;
begin
   errors := 0;
   tolerance := 0.00000064;
   line_count := 1;
   loops := 0;{required so that the special case of 0.00001 is
not counted}
   first_pass := true;
   page := 1;
   x := 0.00001;
  while (x <= 100) do
   begin
         send(0);
           real_send(x);
           y := real_receive;
           diff := (abs(y-ln(x)));
     if diff > tolerance then
       begin
          errors := errors + 1;
          if errors = 1 then
          begin
                write(outlog,'X            Local ');
                writeln(outlog,'ln        Remote ln
Difference',
                                 ' on ',fpp_page_port[i],'
',fpp_page[i]);
                writeln(outlog,'------------------------------
-------------------------------------');
           end;
             write(outlog,x:9:5,'    ',ln(x):11:6);
              writeln(outlog,'    ',y:11:6,'
',diff:8:8);
        end;
        if first_pass then
                begin
                     x := 0.0;
                    multiplier := 0.1;
                    first_pass := false;
          end;
          if loops = 10 then
                begin
               multiplier := multiplier * 10.0;
                    loops := 1;
               end;
          x := x + multiplier;
          loops := loops + 1;
   end;
    if errors <> 0 then
    begin
    bad := 1;
    writeln(outlog);
```

```
    writeln(outlog,errors,' errors have occured in Natural Log
Function.');
    writeln(outlog,'Processor ',i:2);
    writeln(outlog);
    tot_err:=tot_err+errors;
    end;
end;


begin

{ Read the file TESTINFO for the number of times to run this
test. }

  T4:=0;
  reset(TESTINFO);
  if eof(TESTINFO) then
    writeln('File TESTINFO not found, run TESTSETUP');
  if not eof(TESTINFO) then
  begin
    readln(TESTINFO,T1,I1);
    readln(TESTINFO,T2,I2);
    readln(TESTINFO,T3,I3);
    readln(TESTINFO,T4,I4);
  end;
  if T4 = 1 then
  begin
    rewrite(outlog);
    writeln(outlog,'*************************************');
    writeln(outlog,'***** Starting FUNCTION  test. *****');
    writeln(outlog,'***** Iterations = ',I4:6,'      *****');
    writeln(outlog,'*************************************');
    writeln(outlog,' ');

{ Read all the processor addresses from the file funcproc }

    reset(proclist);
    i := 0;
    while not eof(proclist) do
    begin
      i := i + 1;
      readln(proclist,fpp_page_port[i],fpp_page[i]);
    end;
    numProc := i;
    tot_err:=0;

{ Set-up the screen }

    clearscreen;
    gotoxy(8,2);
    write(' ** Floating Point Processor Function Board Test **
');
    gotoxy(0,20);
    write('Testing : ');
```

```
    gotoxy(0,21);
    write('No. of cycles through all boards : ');
    gotoxy(0,7);
    write('Processor : ');

{ Write the number of each processor to be tested on the
screen. }

    for i := 1 to NumProc do
    begin
      if i > 48 then
        gotoxy(13+((i-49)*3),16)
      else if i > 32 then
        gotoxy(13+((i-33)*3),13)
      else if i > 16 then
        gotoxy(13+((i-17)*3),10);
       write(i:3);
    end;

{ Loop for the number of times specified in TESTINFO. }

    cntr:=0;
    while cntr < I4 do
    begin
      cntr:=cntr+1;

{ Run all function tests on each processor. }

      for i := 1 to numproc do
      begin
        gotoxy(36,21);
        write('          ');
        gotoxy(36,21);
        write(cntr-1);
        bad := 0;

{ Set-up a communication channel to the processor being
tested. }

        initialize(fpp_page_port[i],fpp_page[i]);
        turn_on_repeater(fpp_page_port[i],fpp_page[i]);

{ Write an 'M' under the processor number that is to be
tested. }

        if i > 48 then
          gotoxy(13+((i-49)*3),17)
        else if i > 32 then
          gotoxy(13+((i-33)*3),14)
        else if i > 16 then
          gotoxy(13+((i-17)*3),11)
        else
          gotoxy(13+((i-1)*3),8);
        write('  M');
```

```
{ Write the function to be tested to the screen, then run that
function test. }

        gotoxy(11,20);
        write('Sin         ');
        test_sine;
        gotoxy(11,20);
        write('Cos         ');
        test_cosine;
        gotoxy(11,20);
        write('Tan         ');
        test_tangent;
        gotoxy(11,20);
        write('Asin        ');
        test_arcsine;
        gotoxy(11,20);
        write('Acos        ');
        test_arccosine;
        gotoxy(11,20);
        write('Atan        ');
        test_arctangent;
        gotoxy(11,20);
        write('Recip       ');
        test_reciprical;
        gotoxy(11,20);
        write('Exp         ');
        test_exponential;
        gotoxy(11,20);
        write('Square Root ');
        test_square_root;
        gotoxy(11,20);
        write('Natural Log ');
        test_natural_log;

{ Close the communication channel to the processor. }

        stop_processor;
        turn_off_repeater(fpp_page_port[i]);

{ If any result was bad (was out of tolerance), an 'E' is
written over the 'M' under the processor just tested. If all
results passed, then the 'M' is blanked out. }

        if i > 48 then
          gotoxy(13+((i-49)*3),17)
        else if i > 32 then
          gotoxy(13+((i-33)*3),14)
        else if i > 16 then
          gotoxy(13+((i-17)*3),11)
        else
          gotoxy(13+((i-1)*3),8);
        if bad <>  0 then
          write('  E');
```

```
        if bad = 0 then
          write('   ');
      end;
    end;

{ The running total of errors is written to the outlog after
the program finishes. }

    writeln(outlog,'Number of errors = ',tot_err);
    writeln(outlog,' ');
  end;
end.
```

```
program hostio;
var x : real;
begin
  while true do
  begin
    receive(host,x);
    send(host,x);
  end;
end.
```

```
program send;
var mode,x : real;
begin
  x := 0.0;
  while true do
  begin
       receive(host,x);
       send(network,x);
       receive(network,x);
       send(host,x);
  end;
end.
```

```
program receive;
var mode,x : real;
begin
  while true do
  begin
        receive(network,x);
        send(host,x);
        send(network,x);
        send(host,x);
  end;
end.
```

```
{ This program for the processor is the first cut at the T3
diagnostic test.  T3 takes a list of processors and beginning
with the first processor in the list it sends a value to all
the other processors. Then the next processor does the same
thing as does the whole list and then it repeats. Each
transfer (crossbar cycle) the sender/receiver status is
determined by the mode bit (0-send, 1-receive) sent to each
processor by the host. }

program testxbar;
var mode,x : real;
begin

  while true do
    begin
      receive(host,mode);

{receive sender/receiver status from the host}

      if mode = 1.0 then

        begin
          receive(host,x);

{if 1 receive value to send from the host}

          send(network,x);

{and send it accross the network}

        end

      else

         begin
          receive(network,x);

{if 0 receive the value from the network}

          send(host,x);

{and send it back to the host}

        end;
    end;
end.
```

```
program function;
{

    Program            :  Function.PAS
    Programmer         :  Richard A. Armstrong
    Date               :  2/20/89
    Execution State    :  To be run as a remote process

    Purpose    :     The purpose of this program is to receive
an integer from a host program, then to receive a real number
and based on what integer was passed, return a real number
calculated by the function specified by the integer.

}

var
     funct : integer;
     x : real;
begin
     while true do
     begin
        funct := 0;
          receive_lsw(host,funct);
          receive(host,x);
          if funct = 1 then
               send(host,sin(x))
          else if funct = 2 then
               send(host,cos(x))
          else if funct = 3 then
               send(host,tan(x))
          else if funct = 4 then
               send(host,asin(x))
          else if funct = 5 then
               send(host,acos(x))
          else if funct = 6 then
               send(host,atan(x))
          else if funct = 7 then
               send(host,1/x)
          else if funct = 8 then
               send(host,exp(x))
          else if funct = 9 then
               send(host,sqrt(x))
          else if funct = 0 then
               send(host,ln(x));
     end;
end.
```

```
;pretest

; RUN FPPMU

%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3

%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)
```

```
;pretest

; RUN FPPMU

%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3

%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)

;pretest

; RUN FPPMU

%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3
```

```
%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)

;pretest

; RUN FPPMU

%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3

%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)

;pretest

; RUN FPPMU
```

```
%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3

%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)

;pretest

; RUN FPPMU

%0/spock/fpp/amd/reset
%0/spock/fpp/amd/load(proclist=fppmuproc)
%0fppmu(outlog=:LP:,proclist=fppmuproc)

; RUN T2
%1/spock/fpp/amd/reset
%1/spock/reset/resetxbar 5
%1/spock/reset/resetxbar 4
%1/spock/fpp/amd/load(proclist=t2proc)
%1/spock/util/sxbload 5 t2.seq.lft t2.xbar.lft
%1/spock/util/sxbload 4 t2.seq.rgt t2.xbar.rgt
%1/spock/util/masseq 5
%1t2(outlog=:LP:,proclist=t2proc)

; RUN T3

%2/spock/fpp/amd/reset
%2/spock/reset/resetxbar 4
```

```
%2/spock/reset/resetxbar 5
%2/spock/fpp/amd/load(proclist=t3proc)
%2/spock/util/sxbload 5 t3.seq.lft t3.xbar.lft
%2/spock/util/sxbload 4 t3.seq.rgt t3.xbar.rgt
%2/spock/util/masseq 5
%2t3(outlog=:LP:,proclist=t3proc)

; RUN FUNCTION

%3/spock/fpp/amd/reset
%3/spock/fpp/amd/load(proclist=funcproc)
%3ftest(outlog=:LP:,proclist=funcproc)
```

1	200
1	25
1	840
1	250